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OVEN INCREMENT DETERMINATION

By

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In breeding wheat for quality the breeder needs quick and efficient methods. It is for this purpose that a method has been elaborated for determining the oven increment. The oven increment is the difference in average volume between the raised dought and the baked bread, which is a good indication of the baking quality of the flour. The value of the oven increment can be used to characterize the quality of wheat varieties in selecting for baking quality. The importance of the oven increment index number is clearly shown by the correlation coefficients of the oven increment and the major qualitative characters.

Introduction

Today there are many micro-methods available for judging individual qualitative characters (BELDEROK *et al.* 1960). In spite of this the results obtained in producing quality wheat are in many cases unsatisfactory. In the early stages the breeding material can only be selected for a few qualitative characters. In the totally unknown material the value obtained with a single quality testing method is only characteristic of a single factor and in many cases does not give information about the other unknown qualitative factors, nor about their harmonious unity and baking value.

The investigations carried out so far have shown that the harmony of the individual qualitative factors is much more important than the outstanding value of one or another factor. Complex quality testing methods and graphic representation are the most suitable for demonstrating the correlations (POLLHAMER 1967). Unfortunately, this method cannot be used for the early selection of the breeding material, since it is very time-consuming and requires a large number of plants.

As was mentioned earlier, there have been some varieties and strains in recent years for which the internationally accepted method of farinographic qualification is not applicable. Our experiences are confirmed by the data of SEIBEL—CROMMENTUYN (1963), according to whom even the index numbers obtained with the alveograph, amylograph, mixograph and extensograph do not fully characterize the baking quality.

A micro-method is required by means of which the best baking quality strains can be selected with perfect reliability at an early stage of the breeding process. To this end the dough should be tested with a method whose index numbers give a good characterization of the baking quality and make it possible to draw conclusions on the enzymatic state of the dough without further examinations. At present Brubender's Maturograph and Ofentriebgerät seem to be the most suitable for this purpose.

According to SEIBEL—CROMMENTUYN (1963), this apparatus gives a clear picture of the development stage of the dough and of changes taking place during the baking process. These data accurately characterize the baking quality too. SEIBEL—CROMMENTUYN (1964) consider these tests to be highly suitable for determining the effects of various flour treatments, mixing values and additives for improving the quality of the flour. According to their data even if the material is prepared in advance the best laboratory worker can only perform 6 parallel tests, i.e. a total of 12 analyses a day. An average worker is only capable of carrying out 7—8 analyses. These data, together with the experiences of the author, show that owing to the low level of performance this excellent method cannot be used for mass selection of the breeding material.

On the basis of the literary data it was thought that good use could be made of the data from the Maturograph and the Ofentriebgerät if the performance of the instruments was increased. This is all the more important because one of the major tasks of the bakeries is to adjust the volumes of their products to the regulations laid down in the most recent Hungarian standard (ANONYMOUS 1973). Considering the present quality of Hungarian flours this standard is rather strict; high quality basic material and good technology are both required if the standard is to be applied. Since the bakeries aim to produce attractive loaves with a large volume, thoese endeavours must be taken into consideration in breeding for quality.

It is to solve this task that the author has elaborated a micro-method for determining the oven increment; this method seems to be suitable both for judging the quality of the basic material used by the baking industry and to carry out mass selection on the breeding material.

Material and Method

Experimental samples with uniform water content were ground to an average of 60% in a Quadrumat Senior mill. The dough was made with the guaranteed quality Dutch "Fermipan" dried yeast. The amount of water required for the dough was determined in advance by a farinograph. When only a small amount of flour was used the amount of water was determined by a farinograph while kneading the dough.

For each test 50 g flour, 0.30 g Fermipan, 0.50 g salt and the amount of water determined in advance were used. The dough was kneaded for 3 minutes in the 50 g pan of the farinograph. The second sample was kneaded immediately after the first. The average kneading time for the two samples was recorded and this initial time was used in the calculations. After it had been kneaded the dough was placed in a small pot and left to stand in a raising cabinet, first for 40, and, then for a further 30 minutes after being remoulded. After it had stood for 70 minutes and had been moulded for a second time the dough was placed in a slightly oiled heat-proof glass cylinder and levelled off with a cylindrical piece of wood. Then its height (cm^3) was read from the scale on the tide of the glass cylinder (Fig. 1). The dough was then

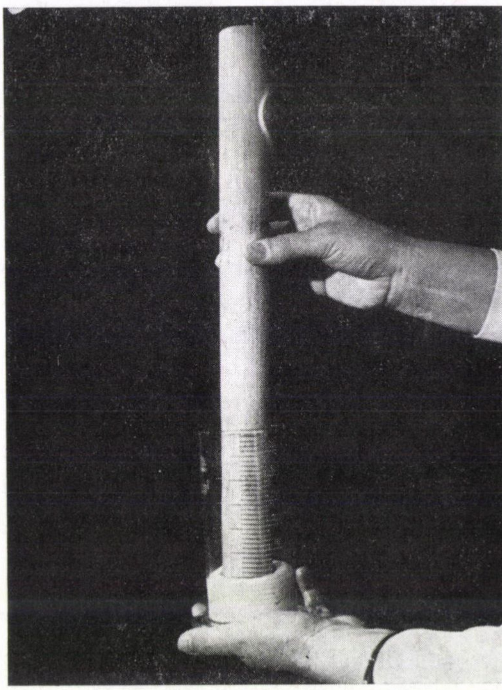

Fig. 1. Placing the dough in glass cylinder and taking the first reading

left standing for a further 30 minutes and the figure read after this period gave the value of the first dough increment (I). After a further 30 minutes of standing the value of the pre-baking dough increment (II), i.e. the height of the dough before baking, was read. The dough increment (I, II) is the difference in volume between the moulded dough placed in the glass cylinder and the dough which has risen prior to baking. When determining the volume of the dough the convex shape was taken into account and the value was read at the average level. This average value is the mean of the figures read at the lowest and highest points of the dough (Fig. 2).

Baking was carried out at 260 °C in an oven manufactured by the Hungarian Labor- és Műszeripari Művek (Laboratory and Instrument Works) (Fig. 3). When the loaves were put in, the oven was adequately humidified, and the loaves were baked for an average of 15 minutes. The oven proved quite suitable for baking small samples.

After baking, the average volume of the product was established with the aid of a metal disc (Fig. 4), and the maximum height was also recorded.

The difference in average volume between dough before baking and bread is the so-called "*oven increment*". The size of the oven increment can be deduced from the average volume of small loaves, the convexity of the surface and the quality of the soft part of the bread (Fig. 5).

For this method heat-proof glass cylinders of special size were manufactured, with an inner diameter of 6.1 cm and a height of 13.5 cm. Each gradation on the side of the glass

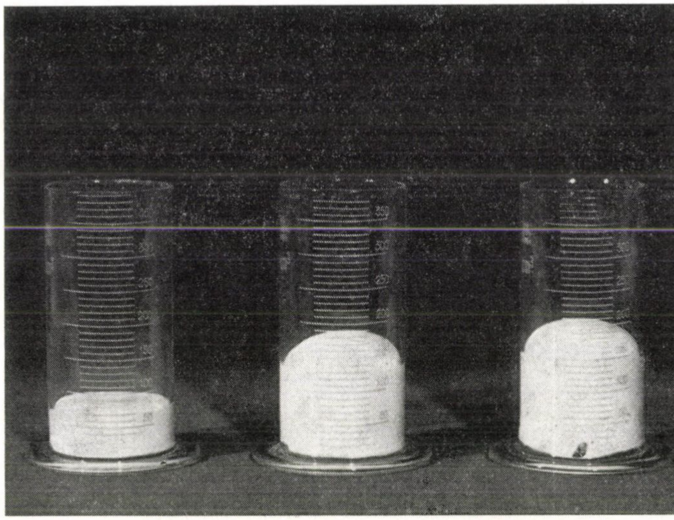

Fig. 2. Establishing the volume of dough (1st glass cylinder = size of dough on placing it in the glass cylinder; 2nd glass cylinder = dough increment I; 3rd glass cnlinder = dough increment II)

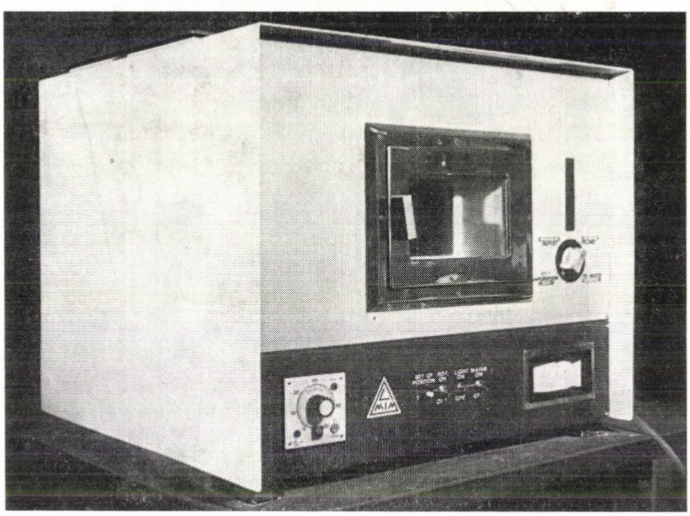

Fig. 3. Experimental oven furnished with automatic heat control and water supply

cylinder represents 10 cm^3; the scale extends to 400 cm^3. This size proved very good for the 50 g flour samples.

The oven increment method was elaborated primarily for the purpose of selecting the breeding material. The usefulness of the method was mainly decided by the speed at which it could be carried out. This was determined in a great variety of tests. With the time schedule presented in Table 1, which has proved to be the best, a semi-skilled laboratory worker can perform 32 tests a day on material prepared and measured out in advance.

In evaluating the method wheat breeding material developed by Balla was used.

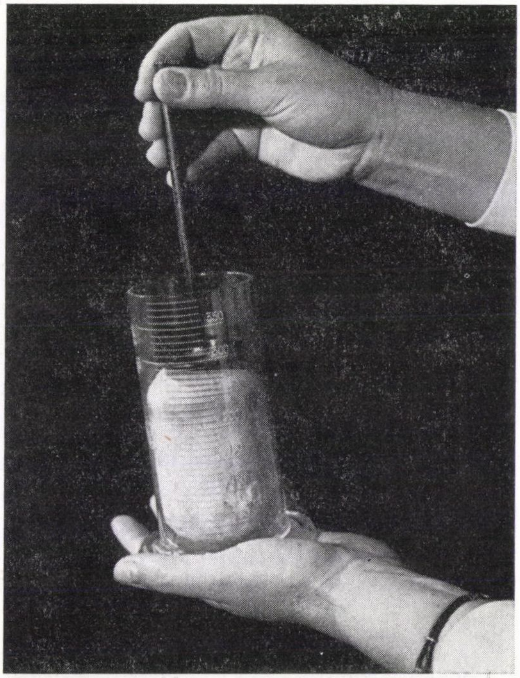

Fig. 4. Measuring the height of bread with the help of a metal disc

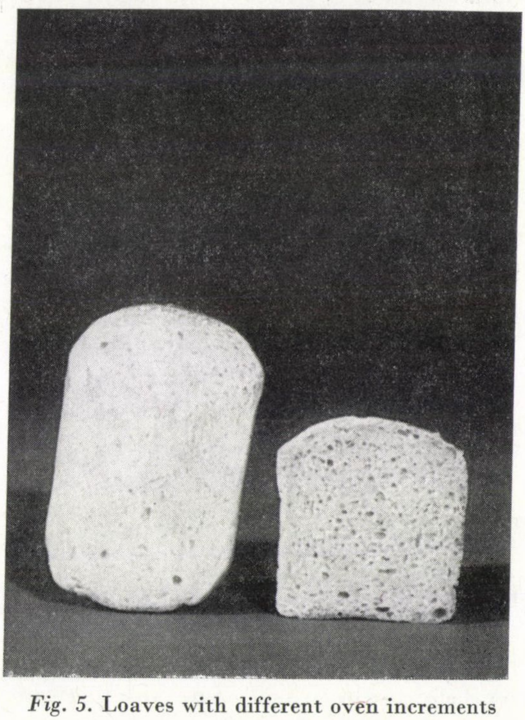

Fig. 5. Loaves with different oven increments

Table 1

Schedule for determining the oven increment
Martonvásár 1975

Time									
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1.	8.20	9.00	9.30	10.00	10.30	10.45	Recording values after baking		
2.									
3.	8.45	9.25	9.55	10.25	10.55	11.10			
4.									
5.	9.10	9.50	10.20	10.50	11.20	11.35			
6.									
7.	9.35	10.15	10.45	11.15	11.45	12.00			
8.									
9.	10.00	10.40	11.10	11.40	12.10	12.25			
10.									
11.	10.25	11.05	11.35	12.05	12.35	12.50			
12.									
13.	10.50	11.30	12.00	12.30	13.00	13.15			
14.									
15.	11.15	11.55	12.25	12.55	13.25	13.40			
16.									
17.	11.40	12.20	12.50	13.20	13.50	14.05			
18.									
19.	12.05	12.45	13.15	13.45	14.15	14.30			
20.									
21.	12.30	13.10	13.40	14.10	14.40	14.55			
22.									
23.	12.55	13.35	14.05	14.35	15.05	15.20			
24.									
25.	13.20	14.00	14.30	15.00	15.30	15.45			
26.									
27.	13.45	14.25	14.55	15.25	15.55	16.10			
28.									
29.	14.10	14.50	15.20	15.50	16.20	16.35			
30.									
31.	14.35	15.15	15.45	16.15	16.45	17.00			
32.									

I. = Varieties, lines
II. = Time of kneading (average of two samples)
III. = Time of first moulding
IV. = Time of second moulding, placing in glass cylinder and reading the first volume in cm^3
V. = Reading the second volume in cm^3
VI. = Reading the third volume in cm^3 and beginning of baking
VII. = End of baking
VIII. = Establishing the average after-baking volume in cm^3
IX. = Establishing the maximum after-baking volume in cm^3
X. = Calculating the oven increment in cm^3

Results

To evaluate the oven increment the following examinations were carried out.

To examine the reproducibility of the method two varieties were chosen: Bezostaya 1, a variety with an average oven increment and high gluten content, and Libellula, which usually has no oven increment and a poor gluten content. The standard deviation varied with the quality type. The deviation in the oven increment for the variety Libellula was 0.26% on average for the 20 samples examined. This means that varieties and strains with no oven increment, which are unsuitable for baking purposes, can be eliminated after a single examination. The deviation in the oven increment in the variety Bezostaya 1 was 1% on average for the 20 samples examined. In the case of better quality varieties, i.e. those with larger oven increments, parallel examinations should be carried out. Fluctuations of more than 1% are due either to inaccuracy in carrying out the examination or supplying the water, or sometimes to doughs with excessively high gluten contents becoming deformed at the top or at the base, or finally to inaccurate reading of the scale.

In order to demonstrate correlations between the oven increment and other qualitative factors the plant material of the 1973 variety trials was used (Table 2). According to the data in the table the oven increment is positively

Table 2

Correlations between the oven increment and various qualitative indices on the basis of data from the 1973 variety trials
Martonvásár 1973

Qualitative indices	Correlation coefficient	Number of varieties examined
Oven increment cm^3 — Micro-loaf volume cm^3	$r = 0.85$	25
Oven increment cm^3 — Macro-loaf volume cm^3	$r = 0.70$	25
Oven increment cm^3 — Complex quality index	$r = 0.70$	25
Oven increment cm^3 — Zeleny number	$r = 0.49$	25
Oven increment cm^3 — Gas retention	$r = 0.41$	25
Oven increment cm^3 — Water absorption %	$r = 0.40$	25
Oven increment cm^3 — Farinograph value	$r = 0.25$	25
Oven increment cm^3 — Wet gluten %	$r = 0.17$	25
Macro-loaf volume cm^3 — Micro-loaf volume (baked in glass)	$r = 0.73$	25

correlated with the micro-loaf volume, the macro-loaf volume and the complex qualitative index number. It is noteworthy that practically no correlation was found between the oven increment and the farinograph value or the wet gluten content. For the baker this means that loaves with a maximum volume and good soft parts cannot always be obtained from flours with outstanding farinograph values and high gluten contents. These tests are thus not sufficient in themselves to provide information about baking quality. Bakeries generally favour flours whose dough rises well in the oven and does not go flat. The oven increment method is much more suitable than the farinograph examinations for characterizing such flours.

The plant material of the 1973 variety trial was well suited for providing information about the oven increments of the different varieties (Table 3). According to the data in the table the varieties Martonvásári 1, Martonvásári 4 and Martonvásári 5 gave the best oven increment values both over the average of the varieties examined and in comparison to the standard variety Bezostaya 1. The oven increments of the varieties Martonvásári 3 and Marton-

Table 3

Oven increment in various winter wheat varieties
Martonvásár 1973

No. of variety	Name of variety	Oven increment, cm³, 1973
13.	Martonvásári 1	40
23.	Mv 26-72 (Mv 4)	40
24.	Mv 32-72 (Mv 5)	35
4.	Rannyaya 12	35
3.	Kavkaz	35
1.	Bezostaya 1	30
5.	Avrora	30
9.	Bánkuti 1201	30
16.	Mv 69-24	30
7.	Jubileinaya 50	25
10.	Bezostaya 2	25
25.	Bezostaya 1 elite	25
20.	Mv 20-72	25
22.	Mv 24-72	20
6.	Mironovskaya 808	20
2.	Fertődi 293	20
15.	Martonvásári 3	15
19.	Mv 09-72	15
21.	Mv 22-72	15
14.	Martonvásári 2	10
17.	Mv 69-07	5
18.	Mv 08-72	5
11.	GK Fertődi 2	5
12.	Kiszombori 1	5
8.	Libellula	5
	Mean	21

vásári 2, on the other hand, proved to be less than average. The data revealed a very great difference between the values for varieties giving the largest and the smallest oven increments. Varieties and strains with small oven increments can easily be distinguished and eliminated from the breeding material.

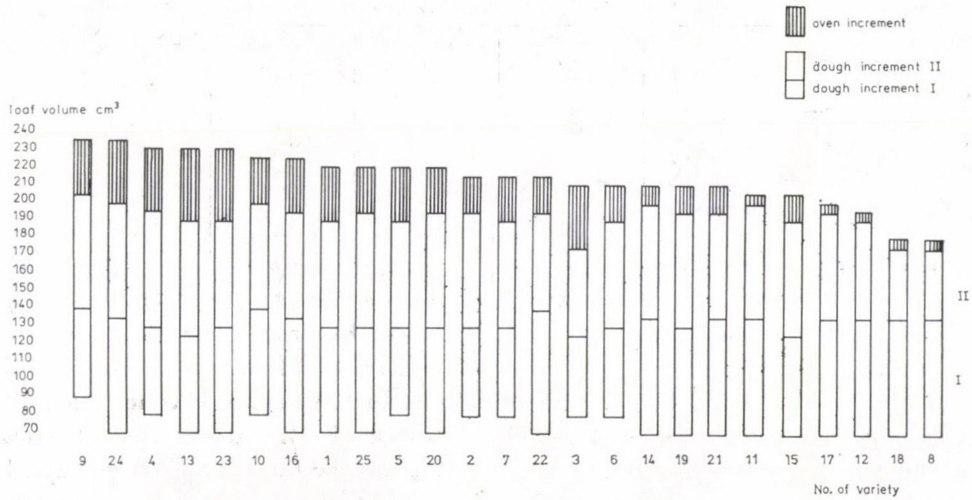

Fig. 6. Graphic representation of dough and oven increments in different varieties

The size of the dough increments (I, II) and the oven increment, as well as the ratio of one to the other, are graphically represented in Fig. 6 for the varieties examined. The varieties were put in order according to the micro-loaf volume. In general, the varieties which produced the largest loaf volume were those which were capable of rising satisfactorily in the oven, as proved by the correlation between the oven increment and the micro-loaf volume. The average initial dough volume was 70 cm^3, though in some varieties the initial value was higher than that. The variety Bánkúti 1201 (No. 9) had an outstanding initial dough volume of 90 cm^3, which can be attributed to its high gluten content. The contradictory oven increment and dough increment ratio in the variety Kavkaz (No. 3) should be mentioned as an exception. If it is milled to 60% this variety is of "B" farinographic quality on average. The good loaf volume (POLLHAMER 1975) is due to the larger than average oven increment. The dough increment, which is similar to that of the variety Libellula (No. 8), is due to the poorer quality of the dough.

The effect of growing site on oven increment was studied on plant material from land leased for experiments by Martonvásár. The size of the oven increment was considerably modified by the different sites (Table 4). According to the data in the table, in 1973 the most favourable oven increment

Table 4

Effect of site on oven increment in different varieties
Martonvásár 1973

Site	Variety			Site average for oven increment, cm^3
	Bezostaya 1	Kavkaz	Rannyaya 12	
	oven increment, cm^3			
Debrecen	75	75	90	80
Baja	45	60	75	60
Abaújszántó	45	55	40	46
Székkutas	40	45	60	48
Eszterág	35	35	55	41
Szombathely	35	40	25	33
Variety average for oven increment, cm^3	45	51	57	

was obtained in the Debrecen and the least favourable in the Szombathely experiment. Between the two extreme values the order was: Baja, Abaújszántó, Székkutas, Eszterág. This order corresponds to the usual meteorological and soil conditions of the experimental sites. In the case of extreme drought the opposite order also occurred (Pollhamer 1975). Among the varieties studied at the different sites Rannyaya 12 gave the largest and Bezostaya 1 the smallest average oven increment, while that of the veriety Kavkaz was found to be of medium size.

At the same sites 7 lines from 2 combinations were examined for oven increment (Table 5). The order obtained for average oven increment agreed

Table 5

Effect of site on oven increment in different lines
Martonvásár 1973

Site	Line		Site average for oven increment, cm^3
	Bezostaya $1_2\times$ Fertődi $293/F_9/3$ strains' average	Bezostaya $1_2\times$ Mironovskaya $808/F_9/3$ strains' average	
Debrecen	57	65	61
Baja	40	44	42
Abaújszántó	37	38	37
Székkutas	48	54	51
Eszterág	35	38	36
Szombathely	28	42	35
Line average for oven increment, cm^3	40	46	

with that in the former experiment, except for Székkutas. On the average for the sites the combination Bezostaya $1\times$Mironovskaya 808 was superior to Bezostaya $1\times$Fertődi 293 as regards the oven increment.

The data in the tables reveal that the oven increment is considerably influenced by the growing site. Grain yields with really high baking quality, i.e. with a large oven increment, can only be obtained under appropriate soil and climatic conditions.

One of the most important phases of breeding for quality is that in which the crossing partners are chosen and their qualitative characters determined. For this purpose the oven increment and the ratio of dough increment to oven

Table 6

Oven increment in foreign winter wheat varieties
Martonvásár 1973

Variety	Oven increment, cm^3
Mironovskaya-Jubileinaya 50	50
Bezostaya 1	45
Kavkaz	45
Starke	45
Virgo	45
Mironovskaya 808	30
Probstdorfer Extrem	30
Helenka	25
Avrora	20
Etoile de Choisy	15
Grana	15
Kranich	10
Cama	10
Diplomat	10
Jubilar	10
San Pastore	10
Sava	10
Bezostaya 1 early	10
Caribo	5
Fertődi 293	5
Capitole	5
Multiweiss	−5
Zlatna Dolina	−5
Joss Cambier	−10
Manella	−10
Capelle Desprez	−10
Champlein	−20
Libellula	−20

increment were determined in 29 foreign winter wheat varieties sown using small drills (Table 6). The varieties are grouped in the table according to the size of the oven increment. In the first five varieties the oven increment ranges between 45 and 50 cm³. In the last seven varieties the dough went flat in the

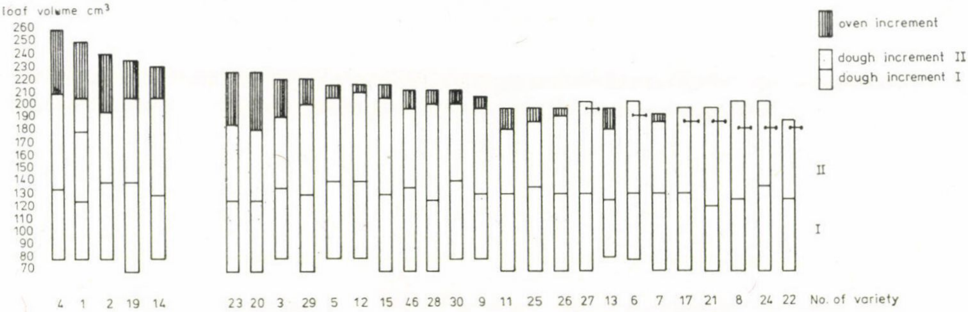

Fig. 7. Dough and oven increments in different winter wheat varieties

oven. The oven increment of Fertődi 293, the only Hungarian variety in the experiment, was again small (5 cm³). The data in Fig. 7 and the order of varieties according to loaf volume again testify that a large loaf volume can only be expected in the case of a large oven increment.

According to the data obtained so far, there are only very few wheat varieties which give outstanding oven increments. In trials on variety collections (1973 yield), for example, the oven increment was excellent or good only in 3.3% of the 150 varieties examined. They included: Lovrin 12, Lovrin 13, Skorospelka 3/b, Skorospelka 35 and Ilyichovka.

Fifteen per cent of the varieties cannot possibly be considered as crossing partners if the breeding aim is to increase the loaf volume (Table 7).

On the other hand, 81.7% of the varieties examined gave medium oven increments. Experience shows that these varieties are worth considering, since when crossed with varieties with a large oven increment and then selected further for this character they may be suitable for producing high quality varieties with large oven increments.

On the basis of the data obtained when examining the oven increments of the 1973 varieties it can be established that there is urgent need of further varieties with large oven increments if varieties with high baking quality, giving large loaf volumes are to be rapidly produced.

In breeding for quality complete success can only be achieved by proper selection on a breeding stock produced from carefully chosen crossing partners with a favourable oven increment.

Table 7

Oven increment in foreign winter wheat varieties
Martonvásár 1973

Variety	Oven increment, cm^3
Zg 4505/68	0
NS 440	0
NS 447	0
Trapezica	0
Slavonka	0
Holcnei	0
NS 622	–5
Sanja	–5
Zg 958/69	–5
Neugaines	–5
Timwin	–5
NB 68513	–5
Neuzucht	–5
Atlas 66	–10
Zg 349/67	–10

The correctness of this view is proved by the data for oven increments and falling numbers in the different combinations (Table 8). According to the data in the table, the average oven increment in strains derived by crossing the varieties Bezostaya 1 and Fertődi 293 is small. This unfavourable value can be traced back to the hereditarily small oven increment and high falling number in Fertődi 293, which is transmitted to the progeny (Figs 8, 9). The values of the variation coefficient and the data in the figures suggest that it is possible to select lines with larger oven increments from the combination.

Table 8

Oven increment and falling number in various lines
Martonvásár 1972

Experiment	Combination	Number examined	Oven increment, cm^3 (aver.)	Variation coefficient %	Falling number (aver.)
C_1	Bezostaya 1 × Fertődi 293	31	32	140.6	568
C_2	Bezostaya 1 × Fertődi 293	22	36	138.8	536
C_3	Bezostaya 1 × Moisson	11	65	69.2	358
C_3	Mironovskaya 808 × Bezostaya 1	8	68	75.5	326

The great importance of the oven increment is also shown by the data for the combinations Bezostaya 1×Moisson and Mironovskaya 808×Bezostaya 1 (Figs 10, 11). The favourable oven increment can be traced back to the lower falling number in the lines of these combinations. As seen in Table 8, when using flour from enzyme-deficient strains with high falling numbers, the

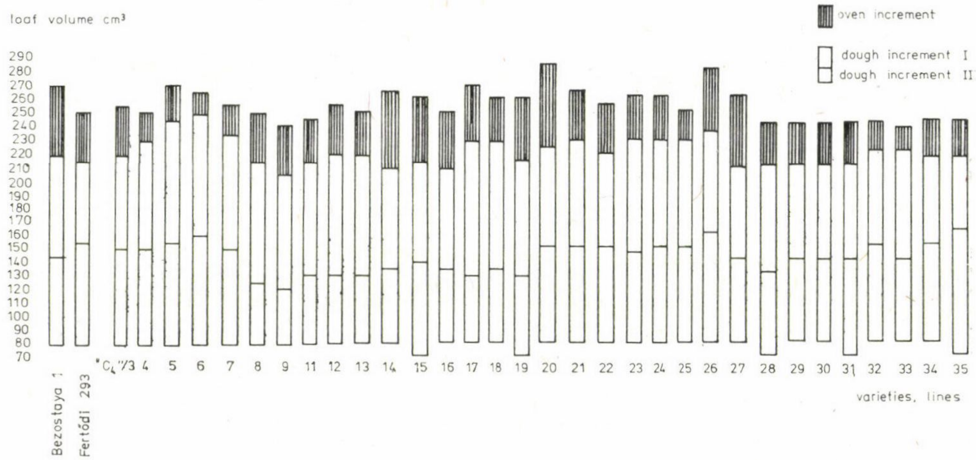

Fig. 8. Oven and dough increments in lines of the combination Bezostaya 1×Fertődi 293 (experiment C_1), Martonvásár, 1972

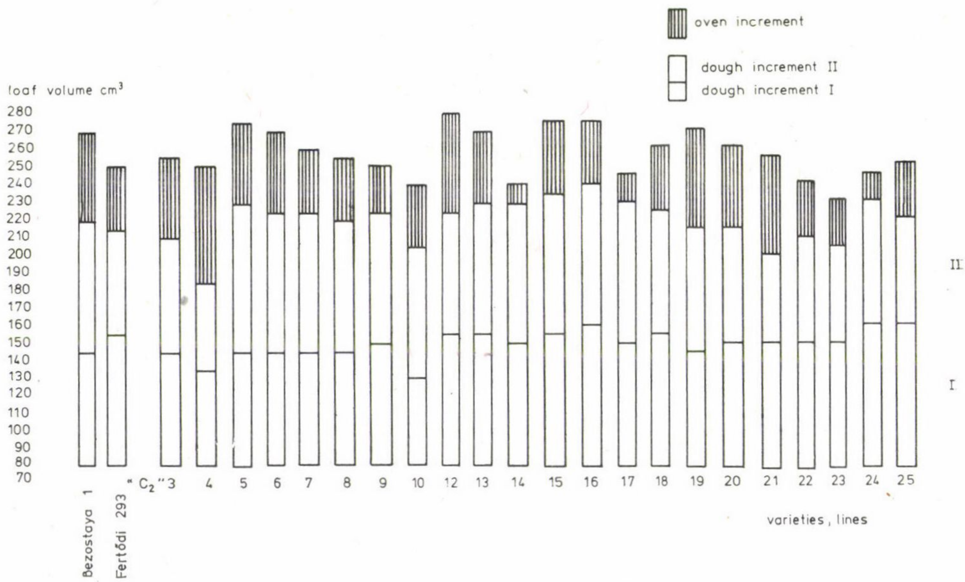

Fig. 9. Oven and dought increments in lines of the combination Bezostaya 1×Fertődi 293 (experiment C_2), Martonvásár, 1972

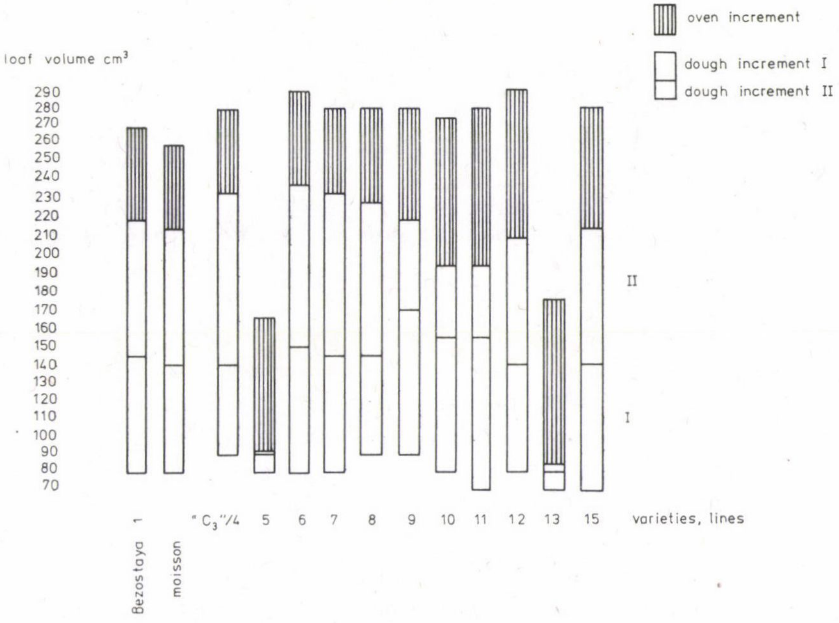

Fig. 10. **Oven and dough increments in lines of the combination Bezostaya 1 × Moisson (experiment C_3)**

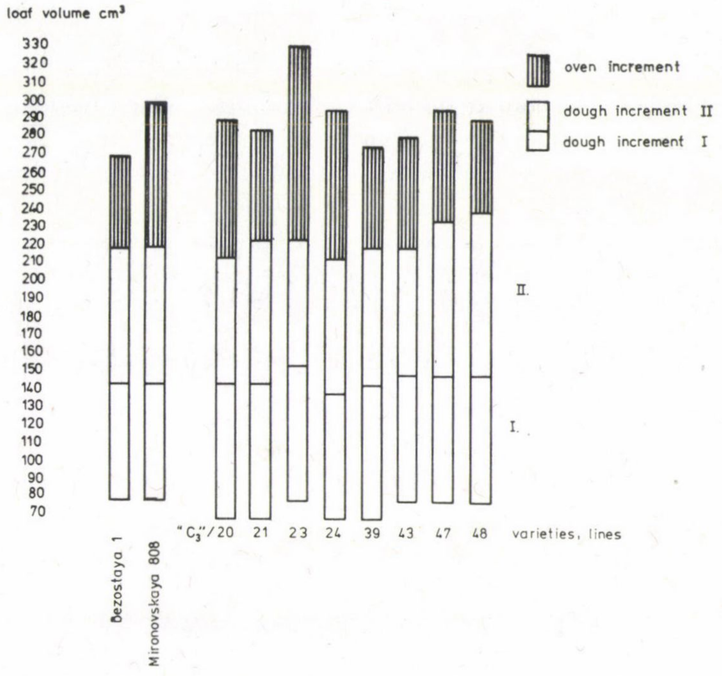

Fig. 11. **Oven and dough increments in lines of the combination Mironovskaya 808 × Bezostaya 1 (experiment C_3)**

loaves obtained had lower oven increments and were thus of smaller volume compared to flour from lines of combinations with optimum falling numbers, even if their other qualitative indices were excellent. This is confirmed by the baking values of the Martonvásár varieties as well. Martonvásári 2 and Martonvásári 3, varieties derived from Bezostaya 1×Fertődi 293, are poor in enzymes and therefore have smaller oven increments. Loaves of bread baked from the flours of these varieties are of smaller volume than those produced from the flour of Martonvásári 4, a variety obtained by crossing Mironovskaya 808 with Bezostaya 1.

These data seem to confirm the view which stresses the importance of choosing the partner correctly and applying the right method of selection.

This method for determining the oven increment could be useful not only in producing new varieties but also when buying up quality wheats. In the latter case the main point is whether the bread produced from the wheat will be of good quality or not; what variety was grown or what agrotechnics were applied are secondary aspects. For this purpose neither the farinograph method, nor the gluten test, nor the examination of falling numbers are suitable in themselves, and sometimes not even in combination. By determining the oven increment, on the other hand, batches with small or non-existent oven increments can be distinguished at once. Low quality varieties with unfavourable falling numbers and varieties which have been incorrectly produced can be spotted by the oven increment method. Good quality varieties or batches of wheat with high oven increment values should be bought at a premium, and the farmers should develop production technologies which lead to large oven increments. By examining the standard varieties the optimum oven increment value corresponding to the given variety and the climatic conditions should be established each year. The evaluation of wheat batches according to oven increment could be carried out by comparing them with the standard varieties in their respective categories. A buying procedure of this kind would ensure that premiums were only given for satisfactory batches. The author suggests that with this method the question of how to grant premiums for quality wheats can be solved.

In Hungary loaves of bread are not baked in tins. Experience shows that baking tins protect the dough from deformation. The population of Hungary prefers rounded loaves baked without tins. Consequently, besides determining the oven increment, the breeder must also select for the roundedness of the bread. It is worth carrying out baking tests by a micro-method (50 g flour) without baking tins on flour from varieties or lines with outstanding oven increments. The shape ratios of such loaves provide adequate information about the roundedness of the loaf. Useful complementary information in connection with the oven increment can be obtained by determining the flexibility of the gluten. These additional examinations are only required when these properties are not yet known for the material in question. When the oven increment is determined for varieties known to contain gluten with low flexibility, complementary examinations are not needed. A good example of the latter case is the variety Martonvásári 3. The loaf volume for this variety must definitely be improved when the quality is checked in the course of variety maintenance. The oven increment examinations carried out for this purpose do not need to be accompanied by other tests, since Martonvásári 3 is known to have flour with a high gluten content of low flexibility and the shape of the bread produced from it is favourable. On the other hand, these additional examinations might be useful in the case of Martonvásári 1.

The data show that the qualitative evaluation of the breeding material requires great care, and the most suitable method must be chosen for selection. On the basis of the above the determination of the oven increment seems to be a very useful method for judging the quality of the breeding material.

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FREQUENCY OF IRREGULAR CELL DIVISION IN PISUM SATIVUM IN RESPONSE TO DIFFERENT RATES OF HERBICIDE APPLICATION CARRIED OUT OVER SEVERAL GENERATIONS

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The herbicides examined, particularly a combination of Treflan and Sevtox, increased the frequency of division abnormalities during mitosis by about ten times compared to the control. A considerable proportion of these abnormalities consisted of anaphase bridges, or of bridges and fragments. Abnormalities in meiosis were found to be less frequent, amounting to about one-third to one-quarter of those in mitosis. Higher (double) rates of herbicide than those specified increased the frequency of obnormalities significantly in most cases. Treatments continued over several generations, on the other hand, decreased rather than increased the frequency. In this case a selective mechanism presumably operates which does not favour the multiplication of individuals with major division abnormalities in the population. This seems to be confirmed by the observation that treatments carried on over several generations, particularly with large doses of Treflan, have the consequence that the stands become substantially thinner.

Introduction

In pea production technology great importance is attached to the use of herbicides, which not only make it unnecessary to weed mechanically or by hand, but also ensure complete plant stands with a larger number of individuals. When peas are grown for processing or feeding purposes the herbicides must satisfy two criteria:

a) They should not have harmful physiological effects resulting in yield reduction.

b) The amount of herbicide residue in the seed or green crop should not exceed the limit laid down in the standard.

In variety maintenance and seed production, where the population is exposed to the direct effects of herbicides over several generations (depending on the number of reproduction steps), further demands are added to the above.

Herbicides should not cause cytological abnormalities in the reproduction processes (mitosis and meiosis) which, when transmitted, may adversely change the genetic structure of the population. Similar harmful effects may be induced in the reproducing population when, in the course of crop rotation, the seed is sown in soil containing herbicide residues which have not yet decomposed, or when, in the case of protective spraying, the wind carries herbicides of undesirable composition or quantity onto the seed production field.

These problems drew attention to the need to study experimentally the subject given in the title. There are a number of useful sources in the literature on the subject. WUU—GRANT (1966) reported chromosome aberrations produced by pesticides in barley and horse bean. They also pointed out that in the progeny (C_2) following the treatment (C_+) the number of chromosome aberrations was much lower, provided no further treatments were carried out. BAYER (1967) reports on the inhibitory effect of trifluralin on mitosis and associates it with the inhibition of root growth. LIGNOWSKI—SCOTT (1972) observed mitosis inhibition in wheat and onion after treatment with trifluralin. According to TOMKINS—GRANT (1976) auxin-base herbicides change the normal movement of the chromosomes during anaphase.

These publications mostly describe the effects of treatments carried out in laboratories. These effects are, however, greatly influenced by the field conditions, so it is difficult to draw conclusions valid for seed producers from results obtained in laboratories. The first accounts of such investigations in peas were given by BADAWI (1973), FÜREDI—BADAWI (1974) and FÜREDI *et al.* (1975), the authors of the present publication. They describe the effects and after-effects of the herbicides and insecticides examined on seed production and the yield components, as well as on the processes of cell division. BEDŐ (1974) studied the effects of the pre-emergent herbicides Olitref, Merkazin and H 8-K, as well as of Aretit and other pesticides applied alone or in combination under laboratory and field conditions.

The present paper contains the results of cytological examinations (in mitosis) of seed samples taken in 1974 during a series of experiments started in 1971 and continued ever since with regular yearly treatments.

When discussing the results, the results of an unpublished earlier investigation, carried out in 1972, are presented for comparison. These show the frequency of irregular cell division in meiosis.

Material and Method

The names and active agents of the herbicides used in the experiment, the method and rate of application and the names of the manufacturers are contained in Table 1.

In Hungary these herbicides were widely used at the beginning of the experimental series and in the year when the samples were taken, and are partly used even today in pea production.

In the cytological examinations the 1974 crop of an experimental series continued for 8 years at the Hatvan—Nagytelek Experimental Station of the Plant Breeding Department was used. The experiments were arranged in a St-block design with several control St-plots per block, a method facilitating the herbicide treatments. Each elementary plot was $4\times$ $\times 1.5$ m $= 6$ m^2 in size and contained 100 germs/m^2 sown by hand. The plots were sprayed with a portable motor sprayer at the times and with the herbicides listed in Table 1, and with the herbicide combinations indicated in Table 2. All the combinations were applied at $1\times$ and

Table 1

Characterization of herbicides used in the treatments

Name	Rate and method of application	Active agent	Manufacturer
1. Treflan	1×; 3.5 kg/ha 2×; 7.0 kg/ha sprayed 24 hours before sowing	26% trifluralin	Elanco Chemical Works, USA
2. Merkazin	1×; 2.6 kg/ha 2×; 5.2 kg/ha sprayed after sowing	50% merkazin prometrin	Budapest Chemical Works, Hungary
3. Sevtox	1×; 4.3 l/ha 2×; 8.6 l/ha on a 15–20 cm stand	20% DNBP	Fisons Ltd., England
4. Aretit	1×; 7 kg/ha 2×; 14 kg/ha sprayed oven an 8–10 cm stand	35% DNBP acetate	Hoechst Chemical Works, GFR
5. Dinoseb*	1×; 4.3 l/ha 2×; 8.6 l/ha sprayed over a 15–20 cm stand	20% DNBP ammonium	Dimitrov Chemical Works, Czechoslovakia

* Only used in the experiment shown in Table 7.

2× doses. Sowing, tending and harvesting were carried out at the time and with the method usual in the area.

In the examination the seed of three samples treated in different numbers of generations were used. The sign + in the table below means that treatment was given in the year marked.

Generation	Year of treatment			
	1974	1973	1972	1971
1	+	+	–	–
2	+	+	+	–
3	+	+	+	+

The number of samples examined, since there were 8 treatments, 3 generations and 2 doses (Table 2), was thus a total of $8 \times 3 \times 2 = 48$.

Five seedlings per sample and 20 preparations made from 4 root tips per plant were also analysed. The total number of preparations examined was thus $20 \times 48 = 960$.

For the cytological examinations the seeds of the samples were germinated between layers of filter paper wetted with tap water for 72 hours (at +20 °C), then after 3 hours of cooling at +2 — —3 °C the root tips were fixed in Carnoy I solution. The preparation was then hydrolysed with 1 N HCl at 60 °C and stained with Schiff reagent. The cytological examination was performed with an NU-universal research microscope, in most cases with a 25×/0.2, 63×/0.8 Planachromat objective and a Pk 16×–20× ocular, with a magnification of 400×–500×, or 1000× if necessary. The abnormalities were identified using the criteria described by Darlington (1965). In the course of the microscope examination the dividing cells and the irregularities in division were counted in each preparation. Finally, the abnormalities were summarized in three groups (Table 2) and evaluated as a percentage of the total number of divisions (Table 3).

The evaluation was carried out by three-factor variance analysis, in the course of which the LSD-value was determined for effects significant on the basis of the F-test. Conclusions were drawn taking this into consideration.

Table 2

Frequeucy of mitotic abnormalities in treatments with various herbicides and herbicide combinations applied over several generations as observed in 40 preparations with an average of 2400 divisions

Herbicides	Number of dividing cells	Bridge + fragm.			Bridge			Other			Total			Total number of abnormalities
		++	+++	++++	++	+++	++++	++	+++	++++	++	+++	++++	
Tre + Sev	7,301	39	34	38	65	53	39	14	24	19	118	111	96	325
Tre + Ar.	7,303	23	27	15	35	30	34	23	10	10	81	57	59	197
Ar.	6,881	21	16	26	33	39	29	8	25	17	62	80	72	214
Sev	7,302	29	27	31	35	38	33	20	22	18	84	87	82	253
Me + Sev	7,411	27	15	23	30	44	26	26	19	30	83	78	79	240
Me + Ar.	7,337	16	13	8	17	32	22	42	31	32	75	76	62	213
Me	6,778	25	3	1	11	24	7	29	41	26	65	68	34	167
Σ	50,313	180	135	142	226	260	190	162	172	152	568	557	484	1,609
$\overline{X}$	7,187	25.7	19.3	20.3	32.3	37.1	27.1	23.1	24.6	21.7	81.1	79.6	69.1	229.9
GM	2,396	21.8			32.1			23.1			76.6/40 prep.			76.6/40 prep.

Frequencies refer to the averages of 1× and 2× doses.

Frequency of abnormalities observed in the control: 11/2400 divisions. Abnormal metaphases, multiple poles and chromosome adhesions were included in the group "other abnormalities".

Table 3

Percentage distribution of mitotic abnormalities in the case of herbicides and herbicide combinations applied over several generations

C \ A	Bridge + fragment			Bridge			Other			Total			$\bar{X}$
	++	+++	++++	++	+++	++++	++	+++	++++	++	+++	++++	
Tre + Sev	1.65	1.40	1.52	2.75	2.18	1.56	0.59	0.99	0.76	4.99	4.56	3.83	4.46
Tre + Ar.	0.94	1.71	0.62	1.42	1.23	1.41	0.94	0.41	0.42	3.29	2.38	2.45	2.71
Ar.	1.04	0.67	1.06	1.63	1.62	1.18	0.40	1.04	0.69	3.07	3.33	2.93	3.11
Sev	1.22	1.10	1.26	1.47	1.55	1.34	0.84	0.89	0.73	3.53	3.54	3.33	3.47
Me + Sev	1.10	0.62	0.92	1.22	1.81	1.04	1.05	0.78	1.20	3.37	3.20	3.15	3.24
Me + Ar.	0.66	0.51	0.33	0.71	1.26	0.92	1.75	1.22	1.33	3.12	3.00	2.58	2.90
Me	1.08	0.12	0.09	0.47	0.98	0.35	1.25	1.67	1.29	2.80	2.77	1.69	2.42
Σ	7.69	6.13	5.80	9.60	10.63	7.8	6.82	7.00	6.42	24.17	22.7	19.96	22.31
$\bar{X}$	1.10	0.88	0.83	1.38	1.52	1.11	0.97	1.00	0.92	3.45	3.25	2.85	3.19
GM		0.94			1.34			0.96			3.18		

Percentages refer to the averages of 1× and 2× doses.
Abnormalities in the control over an average of 2400 divisions: 0.47%.

Results

On the basis of the total number of dividing cells and the number of irregular cases of cell division, it can be established that on average for the 3 factors examined (treated generations, doses and treatment combinations) a total of 60 dividing cells were found in each preparation, of which 1.9—2.0 (i.e. 3.19%) were abnormal. The frequency of abnormalities observed in the control plants is shown at the bottom of the table (Table 2).

The largest proportion of the average abnormalities (76.6) was represented by anaphyse bridges (32.1), while bridge + fragment amounted to 21.8 and other abnormalities to 23.1. Expressed as a percentage this corresponds to 41.9, 28.4 and 30.1%, respectively. However, these averages hide considerable differences, depending primarily on the treatment combination. The largest number of anaphase bridges was observed in the Tre + Sev, and Tre + Ar. treatment combinations (Tables 2 and 3), and the smallest in the Me treatment. The occurrence of bridge + fragment was also more frequent in the Tre and Sev treatments, while in the Me treatments this type of aberration was less frequent.

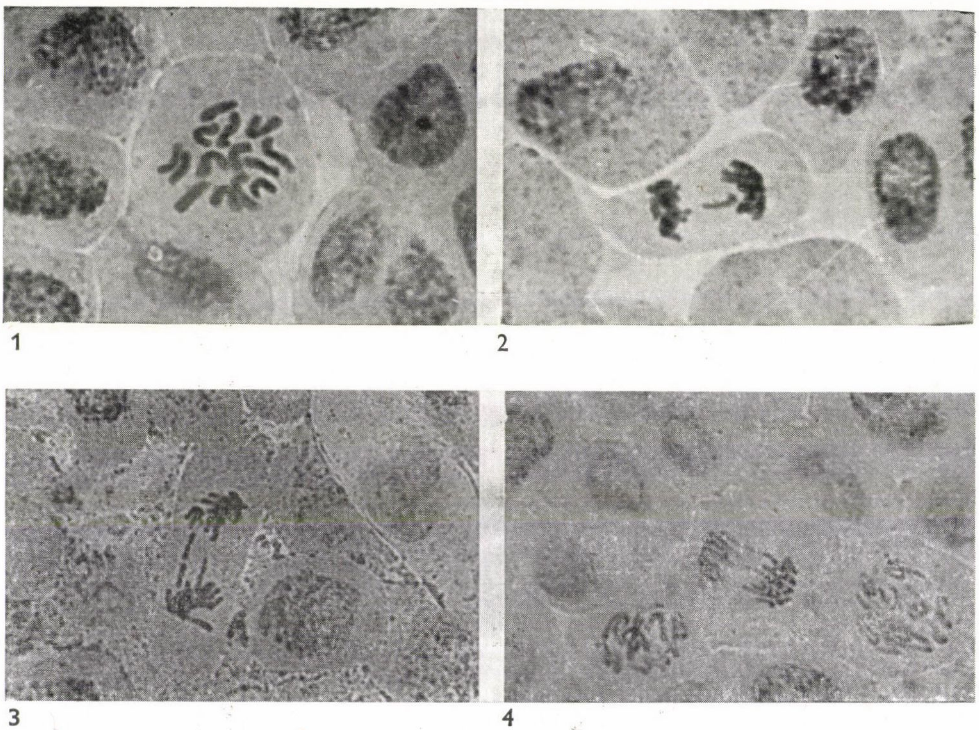


Fig. 1. Mitosis. 1. Normal metaphase with chromosomes easy to count and identify. 2. Anaphase with backward chromosomes. 3. Anaphyse with backward chromosomes. 4. Anaphase with bridge

For other abnormalities the opposite situation was found: they occur in higher proportions in the Merkazin treatment and with a lower frequency in the Treflan treatment. Some type of mitotic abnormalities are shown in Fig. 1.

The actions and interactions of the factors are evaluated taking all the abnormalities into consideration, and are expressed as a percentage of the total number of cell divisions.

On the basis of the MQ- and F-values in the variance table (Table 4) it can be established that the effects of all three factors, when tested against the

Table 4

Table of variance
(Percentage of mitotic abnormalities)

Factors	SQ	FG	MQ	F	F_t	F
A (generation)	2.67	2	1.3350	6.88*	3.88	—
B (dose)	0.97	1	0.9700	12.38*	5.99	—
C (treatment)	15.25	6	2.5416	13.09**	3.00	—
A×B	0.02	2	0.0100	—	3.88	0.33
A×C	2.33	12	0.1941	—	2.69	6.47*
B×C	0.47	6	0.0783	—	3.00	2.61
A×B×C	0.36	12	0.0300	—	—	—
Total	22.07	41	—	—	—	—

* significant at 5%; ** significant at 1%; F_t: fabular F

interactions, are significant. When they are put into order, however, the first place is taken by the effect of the treatment (C), followed by that of the dose (B), while the effect of the generation is last (A).

Of the simple interactions, on the other hand, only the A×C interaction appears to be significant when tested against the A×B×C interaction.

On the basis of the F-test LSD values were also determined for the individual factors, as seen in Tables 5 and 6.

Accordingly, within factor A, treatments carried out over four generations resulted in a significant reduction in the percentage of abnormal division, over the average of the other two factors.

A similar significant increase in the percentage of abnormalities (within factor B) was observed as a result of the larger (double) dose. In confirmation of this statement, for the joint action of factors A and B the highest proportion (3.6%) of abnormalities was obtained with double-dose treatments over two generations, and the lowest (2.71% with normal (1×) treatments over four generations (Table 5).

For treatment combinations within factor C the proportion of abnormalities was the highest (4.45%) in the Tre + Sev, and the lowest (2.43%) in the Me treatment. As regards the joint action of factors A and C, Tre + Sev treat-

Table 5

5/1. Percentage abnormalities in the A × B interaction (140 prep.)

B \ A	++	+++	++++	$\bar{x}$	$LSD_{5\%}$	
1×	3.31	3.07	2.71	3.04	A:	0.36
2×	3.60	3.43	2.99	3.34	B:	0.21
$\bar{x}$	3.45	3.25	2.85	3.19	A×B:	—

5/2. Percentage abnormalities in the A × C interaction (40 prep.)

C \ A	++	+++	++++	$\bar{x}$	$LSD_{5\%}$	
Tre + Sev	5.00	4.55	3.80	4.45	A:	0.36
Tre + Ar.	3.35	2.35	2.50	2.73	C:	0.55
Ar.	3.05	3.10	2.90	3.08	A×C:	0.38
Sev	3.50	3.55	3.35	3.47		
Me + Sev	3.35	3.20	3.15	3.23		
Me + Ar.	3.10	3.00	2.60	2.90		
Me	2.85	2.80	1.65	2.43		
$\bar{x}$	3.46	3.25	2.85	3.19		

5/3. Percentage abnormalities in the B × C interaction (60 prep.)

C \ B	1×	2×	$\bar{x}$	$LSD_{5\%}$	
Tre + Sev	4.37	4.53	4.45	B:	0.21
Tre + Ar.	2.60	2.87	2.73	C:	0.55
Ar.	3.07	3.10	3.08	B×C:	—
Sev	3.13	3.80	3.47		
Me + Sev	2.97	3.50	3.23		
Me + Ar.	2.83	2.97	2.90		
Me	2.27	2.60	2.43		
$\bar{x}$	3.04	3.34	3.19		

$LSD_{5\%}$ values were determined taking into consideration the simple interaction MQ for the main factors and the A × B × C MQ for the simple interactions.

Table 6

Percentage distribution of mitotic abnormalities with herbicides applied at normal (1×) and double rates (2×) over several generations

Variety: Juvel Hatvan—Gödöllő

1974—1976

A / B / C	++		+++		++++		Total		Average (M)		GM	Average		
	1×	2×	1×	2×	1×	2×	1×	2×	1×	2×		++	+++	++++
Tre + Sev	5.1	4.9	4.3	4.8	3.7	3.9	13.1	13.6	4.4	4.5	4.45	5.00	4.55	3.80
Tre + Ar.	3.0	3.7	2.2	2.5	2.6	2.4	7.8	8.6	2.6	2.9	2.75	3.35	2.35	2.50
Ar.	3.1	3.0	3.2	3.4	2.9	2.9	9.2	9.3	3.1	3.1	3.10	3.05	3.30	2.90
Sev	3.2	3.8	3.2	3.9	3.0	3.7	9.4	11.4	3.1	3.8	3.45	3.50	3.55	3.35
Me + Sev	3.1	3.6	2.9	3.5	2.9	3.4	8.9	10.5	3.0	3.5	3.25	3.35	3.20	3.15
Me + Ar.	3.0	3.2	3.0	3.0	2.5	2.7	8.5	8.9	2.8	3.0	2.90	3.10	3.00	2.60
Me	2.7	3.0	2.7	2.9	1.4	1.9	6.8	7.8	2.3	2.6	2.45	2.85	2.80	1.65
Σ	23.2	25.2	21.5	24.0	19.0	20.9	63.7	70.1	21.3	23.4	22.35	24.20	22.75	19.95
M	3.31	3.60	3.07	3.42	2.71	2.98	9.10	10.01	3.04	3.34	3.19	3.46	3.25	2.85
GM	4.45		3.25		2.85		3.03	3.34	3.19				3.19	
Tre	2.4	3.9	2.5	3.2	2.2	3.8	7.1	10.9	2.4	3.6	3.0	3.15	2.85	3.0

ments applied over two generations caused 5%, and Me treatment over four generations only 1.65% abnormalities (Table 5/2).

Analysing the joint action of factors B and C it is found that the double-dose Tre + Sev combination resulted in 4.53% and the normal (1×) dose treatment of Me in 2.27% abnormal cell division (Table 5/3).

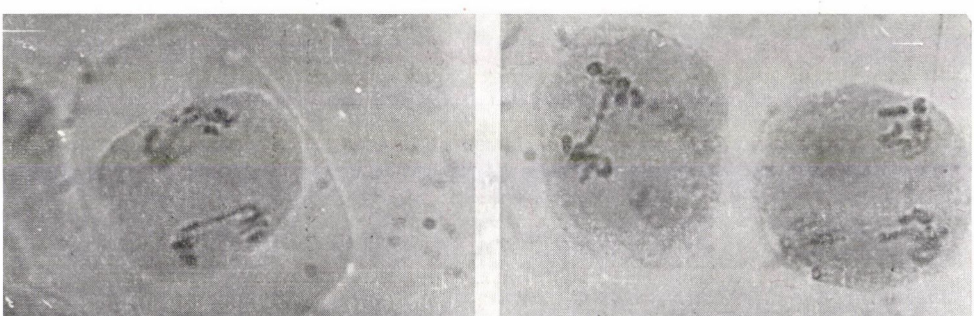
Abnormalities as the joint effect of factors A, B and C were the most frequent (5.1% and 4.9%) in Tre + Sev treatments applied over two generations at normal and double rates, respectively, and the least frequent (1.4%) with the normal rate Me treatment carried out over four generations (Table 6).

With the present method of arrangement and evaluation the significance of the interaction of A, B and C cannot be determined. Taking into consideration the highest estimated LSD value (for factor C this is 0.55) and the 0.4% spontaneous abnormalities observed in the control St-s, this value is presumably greater than 0.5%.

It should be noted that if the evaluation is made according to the negative binomial distribution (Weber 1967), the lowest significant difference (at P = = 0.1%) in the percentage of abnormalities between the control and the treated samples proved to be between 1.0 and 1.5% in most cases.

Taking this value into consideration it can be established that in comparison to the control (0.47%) almost all the treatment combinations increased the percentage of abnormalities significantly, and significant differences were found within and between generations, doses and treatments as well (Table 6).

A similar tendency is shown by the frequency of irregular division in meiosis (Table 7) observed during the cytological examination of primordial anthers in an earlier experiment in 1972 In the latter case, however, the percentage of division abnormalities was much lower (0.87% on average for the whole experiment) than in the mitosis studies (3.19%). Some type of abnormalities in meiosis are shown in Fig. 2.



1 2

Fig. 2. Meiosis. 1. Normal anaphase and anaphase II with bridge. 2. Anaphase II with bridges. Magnification in mitosis: 200×, 25 × (0.50 Planachr obj. × K 10 MF-Projektiv); in meiosis: 400×, 63 × (0.80 Planachr obj. × K 8 MF-Projektiv NU-universal research microscope, with a 24×36 mm camera fixed to it)

Table 7

Frequency of abnormal cell division in meiosis as a percentage of normal division
Variety: Iregi P_3

Treatment, C	A / B	C_+	C_{++}	C_{+++}	Σ	M	D ♯ — ∅
Tre	1×	1.56	0.78	0.76	3.10	1.03	+0.67*
	2×	2.06	1.09	1.10	4.25	1.42	+1.06*
	M	1.81	0.94	0.93	3.68	1.23	+0.87*
Me	1×	0.57	0.40	0.52	1.49	0.50	+0.14
	2×	0.59	0.83	0.66	2.08	0.69	+0.34
	M	0.58	0.61	0.59	1.78	0.59	+0.25
Ar.	1×	0.45	0.47	0.69	1.61	0.54	+0.18
	2×	1.07	1.06	0.95	3.08	1.03	+0.67*
	M	0.76	0.76	0.82	2.34	0.78	+0.32
Di	1×	0.96	0.57	0.56	2.09	0.70	+0.34
	2×	1.30	1.32	0.61	3.23	1.08	+0.72*
	M	1.13	0.94	0.59	2.66	0.89	+0.53*
Σ	1×	3.54	2.22	2.53	8.29	2.76	—
	2×	5.02	4.3	3.32	12.64	4.21	—
		8.56	6.52	5.85	20.93	6.97	—
M	1×	0.88	0.55	0.63	2.06	0.68	+0.32
	2×	1.25	1.08	0.83	3.16	1.05	+0.69*
	M	1.07	0.82	0.73	2.61	0.87	+0.51*
D♯ — ∅		+0.71*	+0.46*	+0.37*	—	+0.51*	

Abnormality with ∅: 0.36%
Abnormality with EMS (ethyl-methane-sulphonate): 2.60%
*: differences larger than 0.36
Year of treatment: C_+ 1971, C_{++} 1972 spring (1st) generation, C_{+++} 1972 autumn (2nd) generation
The data refer to the sum of $M_I + M_{II}$
The frequency ratios in M_I and M_{II} are nearly identical
Abnormalities are of the same type as in Table 2

Discussion

On the basis of the results presented above, it can be established that the herbicides examined, particularly Treflan (active agent: trifluramine) and the hormone-based phenol derivatives Sevtox and Aretit, increase the percentage of irregular cell division in mitosis about 7—8-fold (to 3.2%) compared to the control (0.4%). The percentage of irregular division in meiosis is lower (0.7—1.4%), and is about two to four times as high as in the control (0.36%).

Merkazin, a herbicide containing prometrin as active agent and which is phytotoxic mainly in light sandy soils poor in humus and in fairly dry years, causes cytological abnormalities in mitosis to a significant though lower extent compared to the herbicides mentioned previously.

The highest (9—10-fold) percentage of abnormalities was obtained with the pre- and post-emergent herbicide combinations (Tre + Sev, Me + Sev) and with herbicides applied at a higher than specified rate (2× dose). Although increased doses may improve the weed killing effect, the observance of the specifications is definitely justified in seed production.

Herbicide treatments applied over several (3—4) generations usually decrease (in some combinations by 0.5—1%) rather than increase the percentage of abnormalities. This statement apparently contradicts the experience that treatments, particularly combinations containing Treflan, continued over several generations reduce the seed yield (FÜREDI *et al.* 1975). However, the contradiction disappears when we consider that the reduced seed production is due primarily to the smaller plant number and thinner stand caused by the inhibition of germination. On this basis it can be assumed that a peculiar selection mechanism works in the population to promote the reproduction of plants showing fewer mitotic abnormalities.

This is probably why the frequency of mitotic irregularities becomes less when the herbicide treatments are discontinued (WUU—GRANT 1966, BEDŐ—FÜREDI 1978), and the abnormal germination and thinning of the stands cease (FÜREDI *et al.* 1975).

A similar selection mechanism seems to work at the cell population level, as a result of which the frequency of abnormal divisions in meiosis is much lower, being about half of that observed in mitosis.

The authors intend to carry out further experiments, designed to throw full light on these processes on the basis of the methodological knowledge gained in the present study.

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PRODUCTIVITY AND YIELD ANALYSIS OF WINTER BARLEY

By

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In the 1970—1977 winter barley experiments at the Agricultural Research Institute of the Hungarian Academy of Sciences regular yield analyses were carried out. The average critical values for the yield components in the winter barley breeding material, the yield components of average and maximum annual grain yields, and the average optimum yield components of the Martonvásár winter barley varieties and prospective varieties were established. The relationships between the yield components in the different varieties and years were studied and their importance for breeding and production was evaluated.

Introduction

A relatively large number of data from small plot and farm experiments and a considerable amount of experience is available concerning the productivity of winter barley. The general opinion is that the high potential productivity of winter barley is often not achieved in practice. Of the numerous obstacles to increasing the yield, excessive tillering, lodging due to poor standability and various agrotechnical errors are the most important. In addition, data from regular yield analyses are often not available. Data on winter barley have been published by SZALAI (1970, 1971, 1972) and POLLHAMER (1977). Regular yield analysis offers insight into the relationships between variety and environment and is therefore useful for both the breeder and the producer. With the help of this, the critical values of yield components can be established and yield component combinations providing large yields can be determined for each variety.

Material and Method

To achieve these aims regular yield analyses were carried out on the material of the 1970—1977 line and variety trials on Martonvásár winter barley. The stand density was determined by counting the spikes on a 1 m^2 area, the grain/spike ratio by counting the grains in 25 spikes, and the thousand-grain-weight by weighing two lots of 250 grains each. The yield analysis was performed with the method given by SEDLMAYR (1953) by determining yield components independently of one another.

Results

The 1970—1977 grain yield average in the Martonvásár winter barley material was 55.6 q/ha, 9.2 q/ha more than that of the spring barley material. In the test period the grain yield of winter barley was twice about average, twice above and three times below average. The 1970 grain yield average was obtained with a very low stand density and very high grain/spike ratio and thousand-grain-weight. In 1971 and 1972 the substantially below-average grain yield was again due to the very low stand density. The yield-decreasing effect of the latter could not be counterbalanced even by the considerably above-average grain/spike ratio and thousand-grain-weight. The 1973 grain yield, which was the lowest of all, and the average grain yield in 1974 show that even a higher than average stand density does not always guarantee a large grain yield if, owing to unfavourable conditions during the growth season, the grain/spike ratio or thousand-grain-weight are extremely low. The average grain yield in 1975 was based on more or less average yield components. In 1976 an above-average grain crop was harvested, due primarily to the stand density, which was the highest of all 8 years of the experiment. This stand density, however, proved to be too high, since the grain/spike ratio that year did not reach the value characteristic of the variety, and the thousand-grain-weight was extremely low. The largest grain yield was obtained in 1977 with an above-average stand density and grain/spike ratio and an average thousand-grain-weight (Fig. 1).

The data reveal that the yield components are interrelated and their importance is mainly determined by the order in which they develop. The yield components are greatly influenced by the environmental factors (e.g. soil, weather, agrotechnics) which prevail during their development. An extremely low or high value for any of the yield components may result in a medium or below-average grain yield and may even threaten the yield reliability. The average grain yield for 1970—1978, 55.6 q/ha, was obtained with 487 spikes/m^2, 31.3 grains/spike and a 39.2 g thousand-grain-weight (Fig. 1).

By multiplying spike/m^2 by grain/spike an intermediate yield component is obtained: the number of grains/m^2, which can be read from Table 1. The table reveals that component combinations for a stand density ranging from 350 to 800 spike/m^2 and a grain/spike ratio ranging from 20 to 40 give 14—21 thousand grains/m^2 and in most cases ensure a grain crop significantly higher than average. These values can thus be regarded as the optimum components of the winter barley material. In an average or below-average grain yield at least one of the components is often considerably lower or higher than the optimum value.

Once the yield component number of grains/m^2 has been settled, the size of the grain crop only depends on the thousand-grain-weight (Fig. 2). The thousand-grain-weight of grain yields which are significantly higher than average ranges between 37 and 48 g. Thousand-grain-weights substantially lower or higher than the critical values mostly indicate grain yields significantly lower than average.

A safe basis for a large winter barley grain yield is provided by 350—800 spikes/m^2, 20—40 grains/spike, 14—21 thousand grains/m^2 and a thousand-

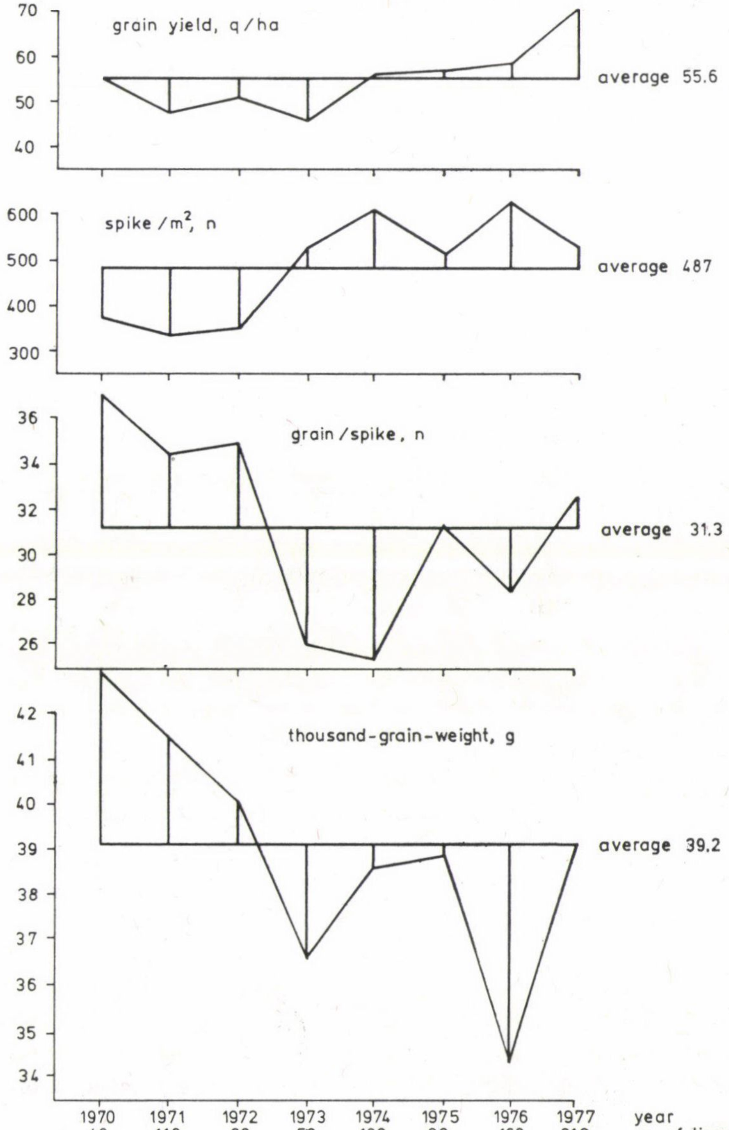

Fig. 1. Average grain yield and yield components in winter barley material. Martonvásár. 1970—1977

Table 1

Deviations in grain yields and yield components from the annual averages in Martonvásár winter barley varieties and prospective varieties
Martonvásár, 1973—1978

Variety	Year	Grain yield, q/ha	Spike/m², n	Grain/spike, n	Grain/m² 1000	Thousand-grain-weight, g
Mv 34	1973	−−	st	−−	−	−
	1974	st	st	st	st	st
	1975	++	st	++	+	+
	1976	st	−	+	st	st
	1977	+	+	+	+	−−
	1978	st	−−	++	st	st
	Average	st	st	+	st	st
	Average	57.0	450	36.0	15.0	38.0
Mv 35	1973	−−	st	+	st	−−
	1974	++	++	st	st	−
	1975	++	st	−−	−	++
	1976	++	++	−−	+	−−
	1977	++	++	st	+	−−
	1978	st	st	st	st	−
	Average	++	++	−	st	−
	Average	59.2	550	30.0	16.5	37.0
Mv 37	1974	st	st	+	st	−
	1975	++	++	+	+	−
	1976	++	++	+	+	−
	1977	++	st	++	++	++
	1978	++	st	st	st	+
	Average	++	+	+	+	st
	Average	66.6	575	32.0	18.4	37.0
Mv 38 prosp. var.	1976	++	−	++	+	++
	1977	++	st	st	st	++
	1978	++	st	+	+	+
	Average	++	st	+	+	++
	Average	69.7	575	30.0	17.3	41.0
Mv 39 prosp. var.	1976	++	++	−−	st	++
	1977	st	++	−−	st	++
	1978	st	++	−−	st	++
	Average	+	++	−−	st	++
	Average	58.8	600	24.0	14.4	42.0
Nursery average:		55.6	487	31.3	15.0	37.0

Signs and abbreviation:
++ Positive deviation more than twice the value of $LSD_{5\%}$
\+ Positive deviation higher than $LSD_{5\%}$
st Value similar to the standard
− Negative difference higher than $LSD_{5\%}$
−− Negative difference more than twice the value of $LSD_{5\%}$

grain-weight of 37—48 g. With such yield components winter barley produced an average grain yield of 55.6 q/ha with an annual fluctuation of 45—70 q/ha. In other experiments the following critical values were obtained for spring barley material: 650—850 spikes/m^2, 17—23 grains/spike, 13—14 thousand grains/m^2 and a thousand-grain-weight of 37—42 g. With such yield components spring barley produced a 46.4 q/ha grain yield over an average of 8 years, with an annual fluctuation of 30—60 q/ha.

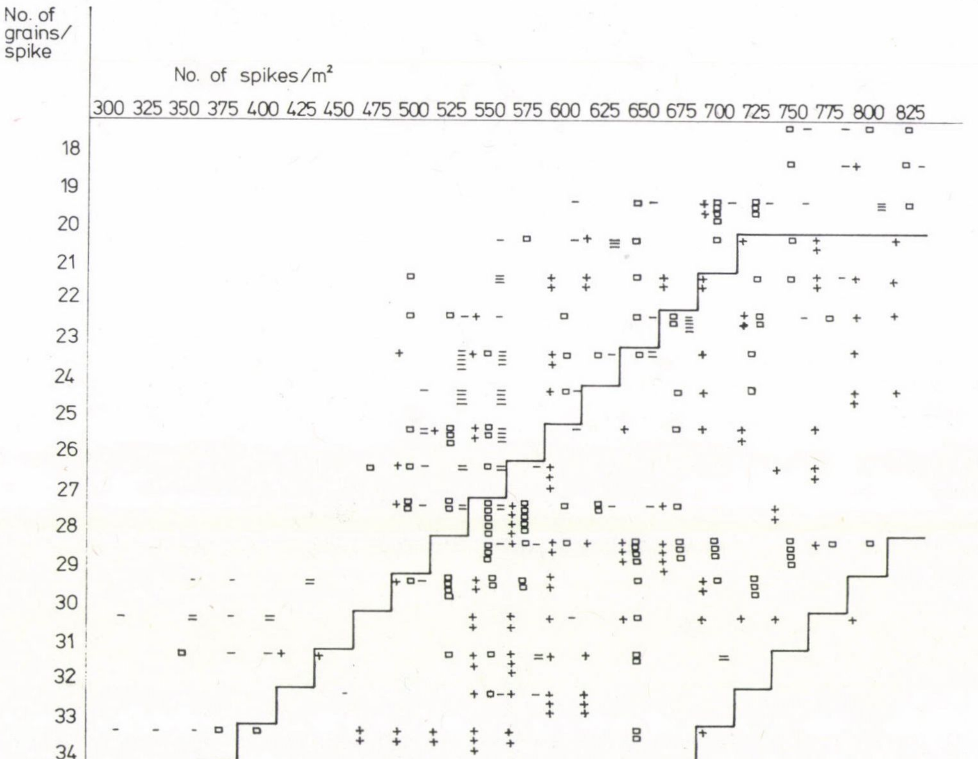

Fig. 2. Number of grains/m^2 in winter barley (1000) Martonvásár, 1970—1977. (+ = Experiment containing 10 varieties with significantly higher then average productivity, □ = Experiment containing 10 varieties with average productivity, — = Experiment containing 10 varieties with significantly lower than average productivity)

Owing to the higher grain/spike values and the larger thousand-grain-weight winter barley can produce a larger grain yield than spring barley even with a considerably lower stand density. In winter barley the yield components

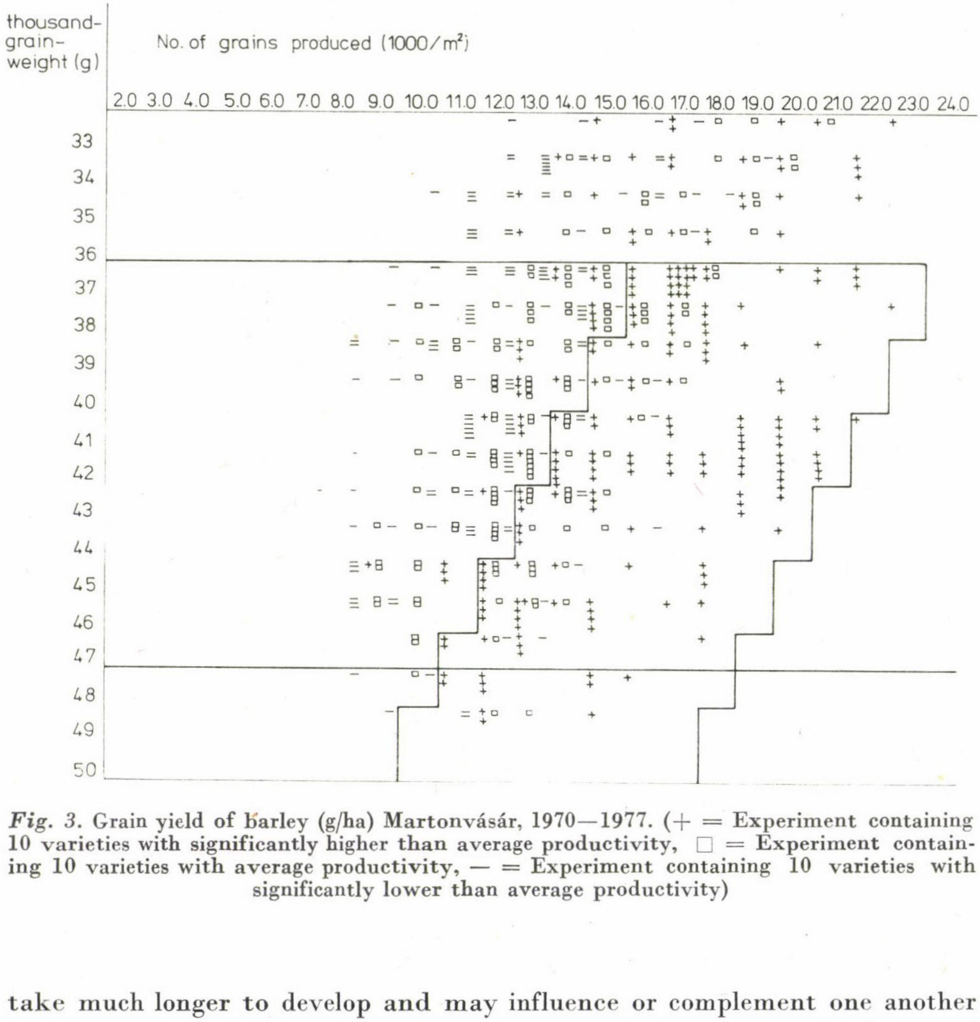

Fig. 3. Grain yield of barley (g/ha) Martonvásár, 1970—1977. (+ = Experiment containing 10 varieties with significantly higher than average productivity, □ = Experiment containing 10 varieties with average productivity, — = Experiment containing 10 varieties with significantly lower than average productivity)

take much longer to develop and may influence or complement one another to a much greater extent than in spring barley. The climatic conditions of Hungary are more favourable for the development stages (particularly for the ripening stage) of winter barley than for those of sping barley, so the adaptability of the former is much better. The higher and more reliable productivity of winter barley is based, among other things, on this fact.

Experiments have proved that in winter barley the size and interrelation of the yield components are characteristic of the variety, but are also dependent on the environmental conditions (Fig. 3). Productivity in the Martonvásár winter barley varieties can be characterized as follows.

The average grain yield of Mv 34 is based on the well balanced, approximately average yield components. Its best yield component, the number of grains/spike, is almost always significantly above-average. Extreme values of yield components occur relatively seldom. The greatest obstacle to increasing the yield is the unsatisfactory standability of the variety.

In the variety Mv 35 the significantly higher than average grain yield is usually due to the large number of spikes/m^2 (high stand density). In some years the excessive stand density prevents the grain/spike component from attaining the value characteristic of the variety, but in most cases the reduction in yield is due to the low thousand-grain-weight. Thinner sowing might greatly increase the productivity of this variety.

The productivity of the winter barley variety Mv 37, which was state registered in December 1978, is significantly higher than average. The large yield is determined by uniformly favourable yield components. The two yield components which develop first have never yet been lower than average. Although, in some years the thousand-grain-weight is low, due to the overdominance of other yield components, it is not generally a critical component. The tillering ability of the variety is low, and its stand density is mainly determined by the number of grains capable of germinating which are sown. Owing to the strong straw the variety tolerates higher rates of nitrogen fertilization. This seems to be the most suitable of Martonvásár's state registered winter barley varieties for the purpose of intensive winter barley production. The propagation and marketing of this variety is a highly important, urgent task.

The prospective variety Mv 38 is considerably more productive than average. Its large grain yield is based on the fact that the yield components are even better balanced than those of the former variety. It represents a new type, because in spite of the above-average stand density its thousand-grain-weight is significantly larger than that of other varieties. The results achieved so far are extremely promising.

The significantly larger than average grain yield of the two-row prospective winter barley variety Mv 39 is based on high stand density and large thousand-grain-weight. Being a two-row variety the grain/spike ratio, quite naturally, is considerably lower than average. Because of the often extremely high stand density and low grain/spike ratio the number of grains/m^2 is only average. Some of its properties may make Mv 39 a valuable new malting barley variety.

It is of importance for the breeder that the great variation in the yield components renders it possible to produce new winter barley varieties with increased productivity and yield reliability. However, good results can only be expected in the future from those varieties in which well-balanced yield components are characteristic of the variety and which do not contain components with extremely high or low values.

The Martonvásár state registered varieties and prospective varieties showed a significantly higher productivity than average in the 1973—1978 experiments (Fig. 3). In several cases the yield components of the varieties deviated considerably from the averages for the experimental sites. If the optimum values determined for the yield components of respective varieties are ensured by means of agrotechnics the potential productivity of a variety can be reliably exploited. Large yields of winter barley can thus be obtained.

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VARIA

VIRUSES OF LETTUCE
III. ISOLATION AND IDENTIFICATION OF LETTUCE MOSAIC VIRUS AND CUCUMBER MOSAIC VIRUS

In previous publications related with viruses infecting the lettuce (Lactuca sativa) and with their host plants (HORVÁTH 1979, 1980a, b) it was pointed out that besides the lettuce mosaic virus (∗/∗ : ∗/∗ : E/E : S/Ap, potyvirus group) the earliest discovered (JAGGER 1921) and most frequently occurring pathogen of lettuce, cucumber mosaic virus (R/1 : 1/18 : S/S : S/Ap, cucumovirus group), has assumed increasing importance (WEIDEMANN–ROHLOFF 1976, SCHMELZER *et al.* 1977). The occurrence of cucumber mosaic virus in lettuce was first pointed out by THOMSON–PROCTER (1965) in New Zealand, then the pathogen appeared in the United States of America (NELSON–MCKITTRICK, 1969, BRUCKART–LORBEER 1975), Italy (RAGOZZINO *et al.* 1971, CANNIZZARO *et al.* 1975), the German Democratic Republic (GIPPERT 1973) and the German Federal Republic (WEIDEMANN–ROHLOFF 1976) too.

On the basis of recently published reports the frequent occurrence of complex infections with lettuce mosaic virus and cucumber mosaic virus, as well as by lettuce mosaic virus and broad bean wilt virus (R/1 : ∗/33 : S/S : S/Ap), has also become known (GIPPERT 1973, ROHLOFF–WEIDEMANN 1976, BRUCKART–LORBEER 1975). According to the data of ROHLOFF–WEIDEMANN (1976) there is a synergistic interaction between lettuce mosaic virus and cucumber mosaic virus; furthermore, it is obvious that the mechanism of resistance shown by the lettuce plant to the two viruses is also different. This is probably the reason why an increasing number of complex diseases in lettuce have recently been described.

Lettuce mosaic virus is the only viral pathogen of lettuce that has been found to occur in Hungary so far (SZIRMAI 1957). This single report on the occurrence of the virus encouraged us to study the occurrence and the properties of the virus pathogens of lettuce.

In the present paper, the third part of a publication series, an account is given of the results obtained in the course of identifying lettuce mosaic virus and cucumber mosaic virus isolated in Hungary.

In the Georgikon Gardens of the Keszthely University of Agricultural Sciences, as well as in private gardens in the Keszthely area, symptoms characteristic of virus infection (vein clearing, light and dark green spots, leaf and stem necrosis, leaf deformation, leaf blistering, leaf-edge curling, growth reduction, head reduction or failure to head, inflorescence and seed reduction, and short seed-stalk) were found in different lettuce varieties (Fig. 1).

In order to demonstrate and identify the viruses that play a role in causing the disease symptoms a large number of isolates were prepared from the different lettuce varieties. The viruses isolated were studied separately.

The leaf samples (10 per variety) collected separately from virus-diseased specimens of each of the nine lettuce varieties ("Aranysárga kőfej", "Attraktion", "Budai hajtató", "Keményfejű", "Május királya", "Soroksári", "Szombathelyi", "Téli vajfej", "Ventura") included in our experiments, were homogenized in a porcelain mortar with 1 : 1 (w/v) phosphate buffer (pH 7.0). The tissue sap thus obtained was applied by means of the carborundum-spatula-buffer technique onto the leaves of *Chenopodium amaranticolor*, *Ch. quinoa*, *Cucumis sativus*, *Datura stramonium*, *Gomphrena globosa* and *Vicia faba* test plants. These virophilous plants are not only susceptible and thereby suitable for the isolation of most virus pathogens of lettuce, but can also be used as dichotomous and semi-separators for the separation of the three most common and symptomatologically indistinguishable virus pathogens of lettuce, i.e. lettuce mosaic virus, cucumber mosaic virus and broad bean wilt virus.

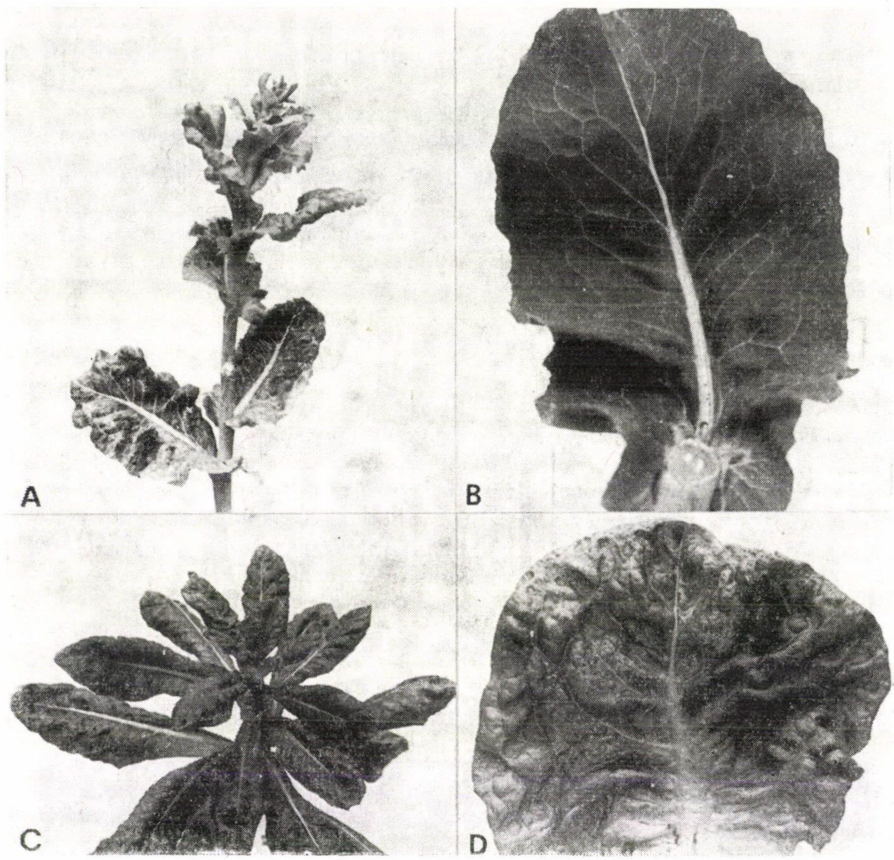

Fig. 1. Leaves of *Lactuca sativa*. A, C, D: naturally infected with lettuce mosaic virus. B: healthy leaf. A, B: *Lactuca sativa* cv. *Attraktion*. C, D: *Lactuca sativa* cv. *Május királya*

While trying to establish the host range of the different virus isolates many test plants were inoculated. In virus transmission experiments the abrasive-spatula technique and the so-called "leaf-to-leaf" method were used. In the course of studying the transmissibility of virus isolates *Myzus persicae* aphids were also used in an attempt to transmit the virus from naturally and/or artificially infected donor plants *(Lactuca sativa* cvs. and *L. virosa)* to various test plants *(Cucumis sativus, Lactuca sativa* cvs., *L. virosa*, *Spinacia oleracea* cv. *Matador)*. After the vector transmission experiments every recipient and test plant was retested on *Chenopodium amaranticolor* indicator plants using the leaf-to-leaf-method.

The physical properties of the virus isolates were determined by the standard method (HORVÁTH 1966); for this purpose *Lactuca sativa* cvs. were used as donors and *Chenopodium amaranticolor* as test and indicator plants.

In morphological studies performed with an electron microscope the so-called leaf dip (shadow-casting) method was used (BRANDES 1957), while in the serological examinations the agar gel diffusion technique was applied (VAN REGENMORTEL 1966, 1967).

Table 1

Reactions of hosts to virus isolates recovered from lettuce (Lactuca sativa)

Lettuce cultivars	Reaction of host plants*					Number of virus isolates in the**		
	Chenopodium amaranticolor	*Chenopodium quinoa*	*Cucumis sativus*	*Datura stramonium*	*Gomphrena globosa*	1st	2nd	3rd
						group		
Aranysárga kőfej	L + S	L + S	R	R	L	3	—	—
Attraktion	L + S	L + S	R	R	L	5	—	—
Budai hajtató	L + S	L + S	R	R	L	4	—	—
	L	L	S	S	L + S	—	2	—
Keményfejű	L	L	S	S	L + S	—	1	—
Május királya	L + S	L + S	R	R	L	5	—	—
Soroksári	L + S	L + S	R	R	L	4	—	—
Szombathelyi	L + S	L + S	R	R	L	2	—	—
	L + S	L + S	S	S	L + S	—	—	2
	L	L	S	S	L + S	—	1	—
Téli vajfej	L + S	L + S	R	R	L	2	—	—
	L	L	S	S	L + S	—	2	—
Ventura	L + S	L + S	R	R	L	4	—	—

* L = local, S = systemic, L + S = both local and systemic, R = resistant
** Ten plants from each lettuce cultivar were examined for the presence of virus(es)

Virus isolates recovered from diseased lettuce plants with the carborundum-spatula-buffer technique were placed in three groups on the basis of the symptoms produced in the virophilous test plants (Table 1).

Isolates in the first group caused local and systemic symptoms in *Chenopodium amaranticolor* and *Ch. quinoa* plants (Fig. 2A and 2B) and local symptoms in *Gomphrena globosa* (Fig. 2C). The inoculated *Cucumis sativus*, *Datura stramonium* and *Vicia faba* plants proved resistant. On the basis of host-virus relations of this type the 29 virus isolates belonging to the first group were assumed to be identical with the lettuce mosaic virus and free of cucumber mosaic virus and broad bean wilt virus components (SCHMELZER 1960, TOMLINSON 1970, BRUCKART—LORBEER 1975, GIPPERT—SCHMELZER 1975, HORVÁTH—SZIRMAI 1975, HORVÁTH 1976, WEIDEMANN—ROHLOFF 1976).

The 6 virus isolates of the second group caused local symptoms in *Chenopodium amaranticolor*, *Ch. quinoa* and *Vicia faba*, local and systemic symptoms in *Gomphrena globosa* (Fig. 2D) and systemic symptoms in *Cucumis sativus* and *Datura stramonium* plants. On the

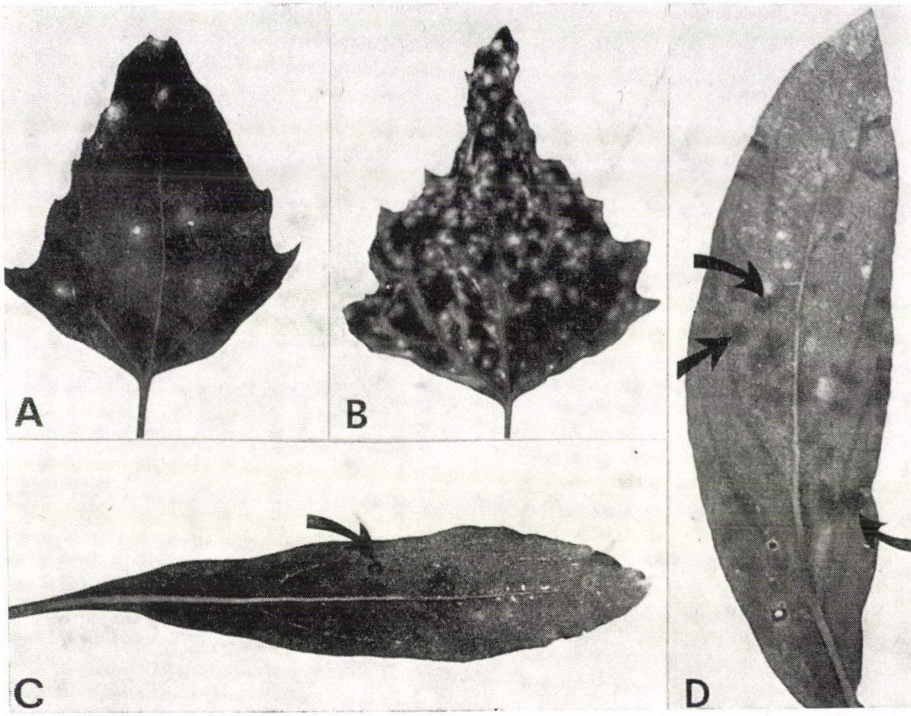

Fig. 2. A, B, C: Symptoms developed by lettuce mosaic virus on artificially inoculated leaves of *Chenopodium amaranticolor* (A, B) and *Gomphrena globosa* (C). A, C: local symptoms, B: systemic symptoms. D: systemic symptoms on the leaf of *Gomphrena globosa* artificially inoculated with cucumber mosaic virus

basis of these host reactions it was assumed that the isolates belonging to the second group were identical with the cucumber mosaic virus and free of lettuce mosaic virus and broad bean wilt virus components (Bruckart—Lorbeer 1975, Horváth 1976, Weidemann—Rohloff 1976).

The 2 virus isolates of the third group, obtained from the lettuce variety *Szombathelyi*, produce local symptoms (characteristic of cucumber mosaic virus) in *Gomphrena globosa* plants. On the basis of the responses given by the examined host plants the conclusion was drawn that the isolates in the third group were of a complex nature and contained both lettuce mosaic virus and cucumber mosaic virus (Bruckart—Lorbeer 1975, Weidemann—Rohloff 1976).

The fact that no isolate of any virus group caused systemic symptoms in *Vicia faba* plants, and that apical necrosis never occurred in *Chenopodium quinoa* plants unequivocally suggest, besides other proofs, that the examined isolates are free of the broad bean wilt virus component. On lettuce plants, according to the authors' observations, no differentiation can be found between the symptoms caused by lettuce mosaic virus and those caused by cucumber mosaic virus; in other words, phenological and symptomatological diagnosis is not suitable for identifying the virus pathogens of lettuce. These observations are in agreement with those made by Schmelzer *et al.* (1977).

In the course of further investigations, only one virus isolate from each of the first and second groups was thoroughly studied. On examining the host range of Mk-4, the isolate obtained from the cultivar Május királya in the first group, the inoculated plants were placed in four groups according to the type of reaction they showed.

Plants belonging to the first group *(Gomphrena decumbens**, *G. globosa*, *Tetragonia crystallina**, *T. echinata*, *T. eremaea**) responded with chlorotic-necrotic local lesions.

Plants belonging to the second group [*Carthamus lanatus** (Fig. 3A), *C. tinctorius*, *Lactuca altaica* (Fig. 3B), *L. perennis*, *L. quercina**, *L. sativa* cvs. Aranysárga kőfej*, Budai hajtató*, Keményfejű*, Május királya*, Soroksári*, Szombathelyi*, Téli vajfej*, *L. sativa*

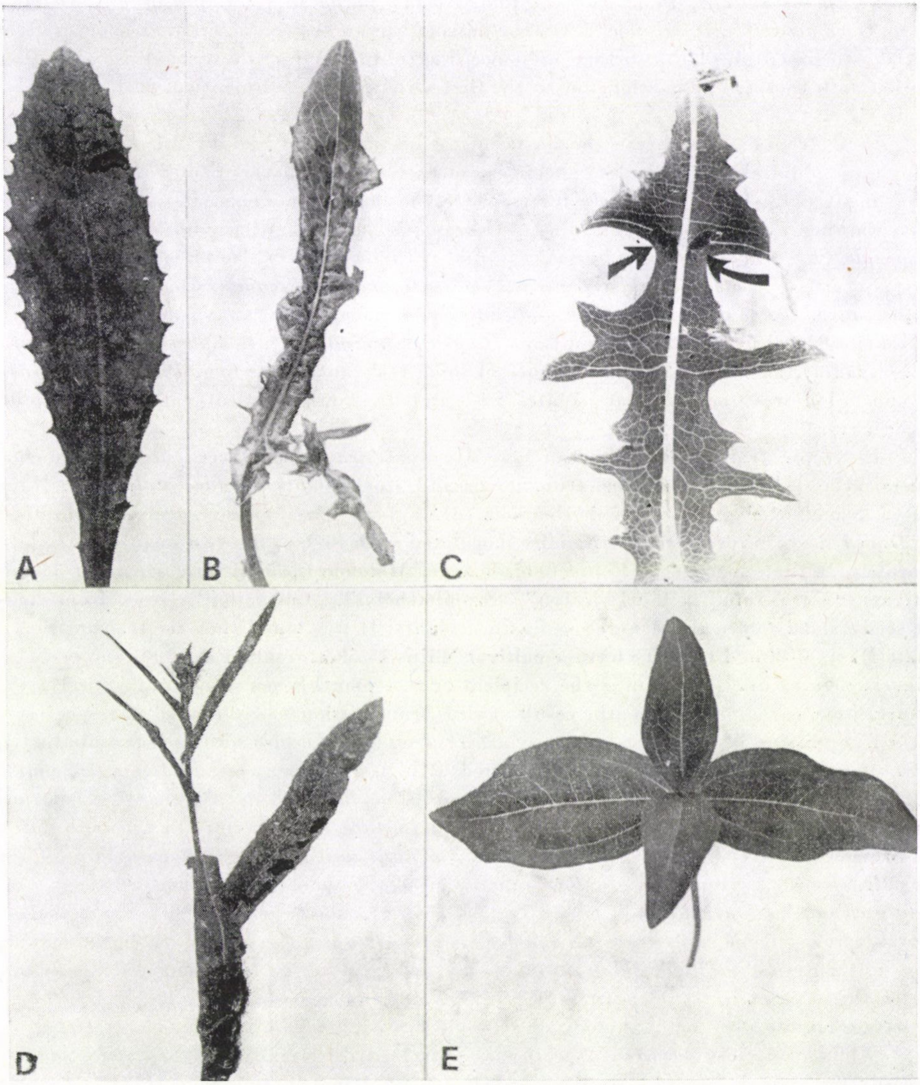

Fig. 3. Systemic symptoms caused by lettuce mosaic virus on *Carthamus lanatus* (A), *Lactuca altaica* (B), *Lactuca serriola* (C, enations indicated by arrows), *Lactuca virosa* (D) and *Zinnia pauciflora* (E)

* Plants marked with an asterisk proved to be new hosts to lettuce mosaic virus.

convar. *inocta* var. *capitata* "Cazard Grosser Gelber"*, *L. serriola* (Fig. 3C); symptoms of necrosis and enation, *L. tatarica**, *L. virosa* (Fig. 3D); symptoms of necrosis and antocyanosis, *Zinnia elegans*, *Z. haageana*, *Z. haageana* cv. *Cocarde**, *Z. pauciflora* (Fig. 3E), *Z. pumila**, *Z. tenuiflora**, *Z. verticillata**] showed systemic susceptibility.

Plants belonging to the third group *(Chenopodium amaranticolor*, *Ch. murale*, *Ch. quinoa)* responded with chlorotic-necrotic local and systemic symptoms.

The fourth group included plants that gave no response to virus inoculated (resistant plants): *Cucumis sativus*, *Datura stramonium*, *Nolana paradoxa***, *N. prostrata***, *Ocimum canum*, *O. carnosum***, *O. sanctum***. On the basis of the known characteristic responses given by the experimental plants further evidence was obtained indicating that isolate Mk-4, together with those isolates belonging to the first virus group, was identical with the lettuce mosaic virus.

In the course of studying the host range of isolates Sz-1 and Tv-2 from the second virus group, obtained from diseased specimens of the lettuce cultivars Szombathelyi and Téli vajfej, many plants were artificially infected. On the basis of the characteristic reactions of plants showing manifest local symptoms *(Amaranthus hybridus*, *Chenopodium amaranticolor*, *Ch. murale*, *Ch. quinoa*, *Lycium chinense*, *Vicia faba*, *Vigna sinensis)*, manifest systemic symptoms *(Cucumis sativus*, *Cucurbita pepo* convar. *patissonina* f. *radiata*, *Datura stramonium*, *Lactuca sativa*, *Malva verticillata*, *Nicotiana glutinosa*, *N. tabacum* cv. *Xanthi-nc*, *Zinnia elegans)* and manifest local and systemic symptoms *(Capsicum annuum****, *Gomphrena globosa*, *Tetragonia expansa)*, as well as by the evidence of some resistant plants (e.g. *Phaseolus vulgaris*) the conclusion was reached that isolates Sz-1 and Tv-2 are identical with the cucumber mosaic virus.

In vector transmission experiments *Myzus persicae* aphids were used to transmit viruses, in a stylet-borne manner, from donor and stock plants (*Lactuca sativa* cvs. Május királya, Szombathelyi), from which the isolated Mk-4 and Sz-1 were respectively obtained, and from *Lactuca virosa* plants artificially inoculated with each of the two mentioned isolates separately. In the experiments, *Spinacia oleracea* cv. *Matador*, *Cucumis sativus*, various lettuce cultivars ("Attraktion", "Május királya", "Szombathelyi", "Téli vajfej") grown from virus-free seeds, and *Lactuca virosa* were used as test plants. It was found that the transmission of isolate Mk-4, obtained from the lettuce cultivar Május királya, resulted in 100% success when *Spinacia oleracea* cv. *Matador* was the recipient or test plant. When using Május királya and *Lactuca virosa* as recipient plants the result of virus transmission was 70 and 90%, respectively. In the transmission of isolate Sz-1 the original lettuce plant (*Lactuca sativa* cv. Szombathelyi), and *Lactuca virosa* plants previously inoculated with Sz-1 isolate, were used as stock plants, and *Cucumis sativus* and *Lactuca sativa* cv. Szombathelyi served as test plants. The transmissibility of isolate Sz-1 from Szombathelyi and *Lactuca virosa* donors to *Cucumis sativus* and Szombathelyi recipients was: Szombathelyi/*Cucumis sativus* = 60%, *Lactuca virosa*/*Cucumis sativus* = 70%, Szombathelyi/Szombathelyi = 80%, Szombathelyi/*Lactuca virosa* = 90%, *Lactuca virosa*/*Cucumis sativus* = 50%, *Lactuca virosa*/*Lactuca virosa* = 90%. Isolates Mk-4 and Sz-1 proved to be easily transmissible by *Myzus persicae* aphids in a stylet-borne manner, using 10 plants per treatment and 10 aphids per plant, to various recipient and test plants, and on the basis of this property the two isolates are analogous (presumably identical) with the lettuce mosaic virus and the cucumber mosaic virus respectively.

While studying the physical properties of isolates Mk-4 and Sz-1 they were found to be easily distinguishable from each other. The thermal inactivation point (TIP) of isolate

** Plants marked with two asterisks are those recently found to be resistant to lettuce mosaic virus.

*** In these experiments *Capsicum annuum* cv. Florida VR-2 was found to respond with local lesions only (without amputation); the virus did not become systemic in the plant.

Mk-4 was 60—62 °C, while the Sz-1 isolate became inactive between 66 and 68 °C. The difference between the two isolates in dilution end-point (DEP) and longevity *in vitro* (LIV) is still greater. These values are a maximum of 10^{-1} and 1—2 days for isolate Mk-4, and a maximum of 2×10^{-5} and 15—18 days for isolate Sz-1. Data on the physical properties of

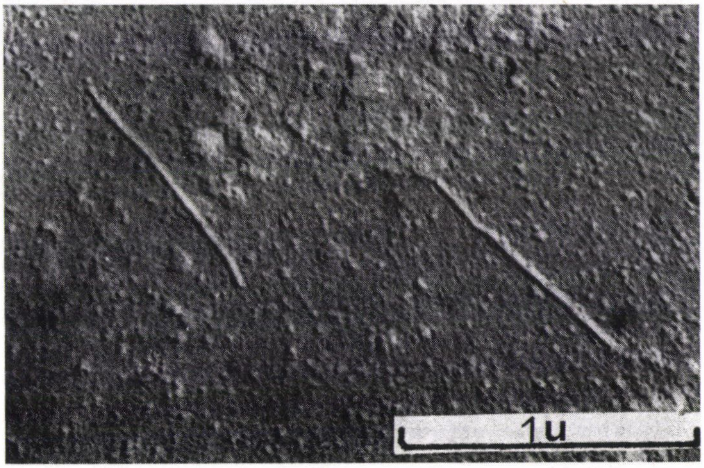

Fig. 4. Lettuce mosaic virus particles. Magnification approximately ×40,000

solates Mk-4 and Sz-1 agree with those presented by earlier literary works for lettuce mosaic virus and cucumber mosaic virus (TOMLINSON 1970, HORVÁTH 1976, SCHMELZER *et al.* 1977).

In the course of electron microscopic examinations carried out with the so-called leaf-dip method isolate Mk-4 was found to be identical with a flexible potyvirus about 750 nm length (Fig. 4), which is identical with the lettuce mosaic virus (TOMLINSON 1970, EDWARDSON 1974).

In agar gel diffusion serological tests isolate Sz-1 proved to be identical with the cucumber mosaic virus, and serologically similar to the cucumber mosaic virus isolates earlier reported in Hungary (HORVÁTH 1976).

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PHYTOPRODUCTION OF PERENNIAL GRASSES

Studying perennial grasses with different ecological demands in single-species grass plots is justified from biological and production points of view alike. If a number of perennial grasses are grown simultaneously for several years under identical site conditions it is possible to study the natural succession of these grasses, select the species producing the largest phytomass with the highest feeding value and introduce them in commercial production within the given regional unit.

In the present experiments the aim was to study under natural conditions 15 perennial grass species *(Agrostis alba, Puccinellia distans, Trisetum flavescens, Poa trivialis, Festuca, rubra, Festuca pratensis, Alopecurus pratensis, Poa pratensis angustifolia, Festuca arundinacea Lolium perenne, Arrhenatherum elatius, Bromus erectus, Bromus inermis, Festuca pseudovina, Festuca sulcata)* for their capacity to form a stand, and to follow the seasonal and yearly fluctuations of the planted and invading species, and the trend of yield on the basis of several years' cultivation as a function of changes in the weight ratio between top growth and root mass.

In phytoproduction experiments planned to cover several years it is possible to follow the development of stands of grass species with different ecological demands *(hygro-mesophilous, mesophilous, xerophilous)* from planting until they reach their first maximum phytoproduction, and from there to complete structural deterioration, under soil and climatic conditions characteristic of the given regional unit, with fertilization, irrigation and chemical weed control totally excluded.

With the information on the development of the different grass stands under natural conditions (without irrigation or fertilization) obtained from the experimental results the phytoproduction can be evaluated at control level, and of the 15 species included in the experiment those most suitable in the long run for high-yielding, intensive grass plantation on meadows and pastures in the environs of Gödöllő can be selected. Below, the production results obtained in three successive vegetation periods following plantation are presented.

The microplot grass experiments were carried out on the Szárítópuszta trial grounds of the Gödöllő University of Agricultural Sciences in 1974—1976. After previous autumn and spring soil preparation plots of 4 m^2 each were sown on 15th March 1974 with grass seed produced at Szarvas. Sowing was followed by three applications of starter irrigation, each accompanied by 10 mm irrigation water. The soil of the experimental area was slightly eroded rust-brown forest soil over loess-sand basic rock, the characteristic data of which are summed up in Table 1. The major meteorological data of the three years are contained in Table 2.

Table 1

*Characteristic soil data**

Sampling depth, cm	pH in water	$CaCO_3$, %	Viscosity index	Humus, %	Water permeability, mm/hour		Gap volume, %	HV	Max. water capacity
					Kazó type	capillary		Gap volume	
0— 31	7.6	tr.	30	1.12					
31— 64	7.9	tr.	36	0.42					
64— 82	8.3	14.1	35	0.54	34	151.7	48.1	4.7	46.6
82—111	8.4	33.4	30	—					
111—160	8.4	17.1	32	—					

* Slightly eroded rust-brohn forest soil on loess-sand basic rock, with loamy sand in the ploughed layer.

Table 2

Characteristic
(Szárító-

Months	I.	II.	III.	IV.	V.	VI.
						1974
Precipitation, mm	38.2	44.2	7.9	20.7	66.8	56.5
Mean temperature, °C	0.0	4.3	8.7	10.9	14.3	17.4
Total amount of heat, °C	121.2	121.2	270.2	326.1	444	522.3
Number of sunshine, hours	32.2	94.4	188.9	204.9	205.2	202.3
Air humidity, %	91	78	60	51	70	66
						1975
Precipitation, mm	6.8	6.2	26.5	37.1	32.7	84.7
Mean temperature, °C	1.5	0.5	7.7	10.5	17.9	19.1
Total amount of heat, °C	46.4	14.5	238.3	315	555	571.8
Number of sunshine, hours	89.3	147.7	121	183.7	215.7	222.8
Air humidity, %	86	69	70	64	67	70
						1976
Precipitation, mm	67.1	5.4	29.4	66.4	28.3	34.4
Mean temperature, °C	−0.1	−0.9	−3.8	11.8	15.9	19.5
Total amount of heat, °C	−3.8	−25.9	−118.4	352.7	491.7	586.4
Number of sunshine, hours	61.9	101.2	164.8	207.7	251.8	315.7
Air humidity, %	81	81	70	61	63	56
						50-year
Precipitation, mm	32	32	37	45	63	61
Mean temperature, °C	−2.4	−0.9	4.3	9.5	14.9	17.8
Number of sunshine, hours	66	83	141	178	245	259
Air humidity, %	83	80	73	67	67	65

The evaluation of the grass crop was carried out after a preliminary coenological survey by test cutting on one or two occasions in the first year and on two occasions from the second year on, depending on the development stage of the grass stand. The first cutting and sampling was done in the phenophase of flowering, the second at the end of September or the beginning of October after the development of the second growth, on the dates indicated in the tables. The grass crop was weighed when fresh and dried (105 °C), each in four replications. The root mass of the planted grass stands was examined by the soil monolith method (Kovács—Gáspár 1974, 1975). Similar methods have been used in studying the weight ratio of aboveground to belowground phytomasses of grasses by a number of Hungarian (Koltay—Précsényi 1956, Kovács—Czinkóczky 1974, Barcsák—Petrányi 1960) and foreign authors

meteorological data
puszta)

VII.	VIII.	IX.	X.	XI.	XII.	Yearly average	IV—IX.
41.3	52.8	46.3	152.5	36.1	39.4	572.7	284.4
20.1	22.4	16.4	7.0	4.8	2.5	10.7	16.9
624.2	695	492.8	217	144	77.7	3935.7	3104.4
276	261.6	172.9	65.4	66.5	52.9	1636.2	1322.9
60	63	71	85	81	86	72	63
136.1	65	51.6	53.7	20.2	37.2	557.8	407.2
21.1	20.1	18.4	10.2	2.7	0.2	10.8	17.8
655.6	624.1	551.2	315.7	81.9	7.7	3977.2	3272.7
287.8	210.1	222.6	140.4	60.8	91.3	1993.2	1342.7
69	73	74	80	85	86	74	70
66.4	18.2	136.5	83.6	45.2	110.3	691.2	350.2
22.7	18.4	14.8	10.7	5.7	−0.4	9.5	17.2
703.4	570.8	444.8	331.7	169.9	−12.8	3490.5	3149.8
311.3	249.1	120.2	90.1	40.2	55.2	1969	1456
71	63	81	91	92	89	75	66
average							
50	50	44	50	56	44	564	313
19.9	19	14.8	9.3	3.3	−0.4	9.1	16
291	264	194	132	60	47	1960	1431
65	67	73	79	85	87	74	67

(Belorussova—Mescheriakova 1973, Canell—Drew 1973, Hein—Enno 1973, Iwaki—Midorikawa 1968, Lebediev—Makovsky 1973, Raktyeenko—Yakushev 1968, Troughton 1957, etc.). The soil monoliths required for the root examinations were taken to a depth of 0—40 cm in four replications simultaneously with test cutting. To obtain reliable root samples two samplers of different size (10 dm^3, 1 dm^3) were tested simultaneously. A comparison showed the 1 dm^3 sampler to be more suitable. The soil monoliths were lifted with samplers made of $10 \times 10 \times 10$ cm iron plates and the roots were washed out. The washed roots were weighed when fresh and dried (105 °C), and their volume was measured. The aboveground and belowground phytomasses of the individual grass stands were evaluated per unit area (m^2, ha). The present paper contains the results of processing 312 grass samples and 1248 root samples.

Table 3

Yield trends of grass stands planted with one

Planted species	1974						
	15th June		7th October		Total		19th
	fresh	dry	fresh	dry	fresh	dry	fresh
1. *Agrostis alba*	—	—	196.75	90.75	196.75	90.75	50
2. *Puccinellia distans*	87.25	20.75	39.94	9.5	127.19	30.25	32
3. *Poa trivialis*	—	—	143.2	48.75	143.2	48.75	73
4. *Alopecurus pratensis*	—	—	277.5	78.25	277.5	78.25	65
5. *Trisetum flavescens*	—	—	56.5	22.75	56.5	22.75	63.5
6. *Festuca rubra*	—	—	97.5	42	97.5	42	72.4
7. *Festuca pratensis*	202.5	44.75	257.75	70.25	460.25	115	170.5
8. *Festuca arundinacea*	168.75	35.37	224.25	64.5	393	99.87	210
9. *Arrhenatherum elatius*	—	—	—	—	—	—	71
10. *Lolium perenne*	166.25	33	272.5	77	438.75	110	165
11. *Poa pratensis angustifolia*	—	—	—	—	—	—	31
12. *Bromus inermis*	111.25	25.75	134.25	39.5	245.5	65.25	162
13. *Bromus erectus*	—	—	29.75	16.75	29.75	16.75	24.25
14. *Festuca pseudovina*	—	—	73.75	33	73.75	33	38.5
15. *Festuca sulcata*	—	—	97.5	42	97.5	42	64.75

1. *Agrostis alba* L. stand

From the 2.5 g seed sown, 8775/m^2 seedlings came up. In the year of sowing a pure grass stand with 90% cover developed. In the second year the stand closed completely, reaching 100% cover; the proportion of alien species was 2%. In the third year cover by the sown species decreased (90%), while the share of the alien species increased to 10% *(Festuca arundinacea, Setaria viridis, Echinochloa crus-galli, Erigeron canadensis, Hibiscus trionum, Trifolium campestre)*. This highly water-intensive grass stand, which in the present case developed under relatively arid conditions, produced the largest yield in the year of sowing, and less than half of this in the third year (90 and 39 q/ha dry matter, respectively) (Table 3). The root mass in the 0—40 cm soil layer showed a steady increase in weight from the first year onwards (except for the depression caused by the 1976 summer drought) in spite of the gradually decreasing crop. The root mass sampled when the test cuts were made weighed many times as much as either the fresh or the dry crop in all but the first year (Table 4). The weight ratio of dry aboveground to belowground plant parts at the test cutting was 1 : 0.7 in 1974, 1 : 9 and 1 : 11 in 1975 and 1 : 20 and 1 : 5 in 1976. Under relatively arid conditions this highly water-intensive grass stand was not able to compensate for the continuous decrease in aboveground phytomass production even by a rapid development of the root system.

2. *Puccinella distans* (Jacq.) Parl. stand

From the 2.5 g seed, 5950/m^2 seedlings developed. This halophitic, vigorously sprouting perennial hygro-mesophilous species showed intensive development even in the year of sowing and attained a 95% cover. By the end of the third year the sown species covered 70%, and *species each in the years 1974—1976 (q/ha)*

1975					1976					
May	15th September		Total		9th June		10—16th September		Total	
dry	fresh	dry	fresh	dry	fresh	dry	fresh	dry	fresh	dry
16.11	101.0	29	151	45.11	27.5	8.86	70	30.43	97.5	39.29
7.61	35.75	18.5	67.75	26.11	65	19.9	43.75	21.87	108.75	41.77
31.51	63.5	18.0	136.5	49.51	90	38.85	37.5	17.63	127.5	56.48
24.22	65.75	24.75	130.75	48.97	72.5	27.62	43.75	20.88	116.25	48.5
20.42	109.5	28.75	173	49.17	62.5	18.38	52.5	23.49	115	41.87
24.25	112.75	35.25	185.25	59.5	47.5	17.03	60	35.45	107.5	52.48
46.64	114.5	45	285	91.64	110	53.35	47.5	23.04	157.5	75.39
49.94	211	60.25	421	110 19	82.5	29.57	76.25	34.75	158.75	64.38
16.64	75.25	24.25	146.25	40.89	137.5	55	75	36	212.5	91
59.67	100	31.5	265	91.17	72.5	26.22	43.75	19.03	116.25	45.25
9.87	66.5	22	97.5	31.87	55	20.75	38.5	19.65	93.8	40.4
38.28	91.5	39.25	253.5	77.53	115	27.22	42.5	25.5	157.5	52.72
9.09	67	26.25	88.25	35.34	47.5	17.81	51.25	27.25	98.75	45.06
16.71	40	18.15	78.5	34.86	30.0	15.31	25.5	14.09	55.5	29.4
15.6	60.75	17.25	125.5	32.85	90	45	45	22.5	135	67.5

the intruder perennial and annual species *(Agropyron repens, Festuca sulcata, Bromus inermis, Lolium perenne, Achillea collina, Trifolium arvense, Taraxacum officinale, Reseda lutea, Artemisia vulgaris, Erigeron canadensis, Capsella bursa-pastoris, Setaria viridis)* covered 30% of the area. The crop yield (dry matter) was 30 q/ha in the first, 26 q/ha in the second and 41 q/ha in the third year (Table 3). The dry weight of the roots (in the 0—40 cm layer of soil) tripled compared to the first year, and from the second year on it showed the seasonal fluctuation characteristic of grasses (Table 4). From the second year 80% of the dry root mass was concentrated in the 0—10 cm soil layer. The weight ratio of dry aboveground to belowground plant parts at the time of cutting was 1 : 2 and 1 : 6 in 1974, 1 : 17 and 1 : 6 in 1975, and 1 : 13 and 1 : 7 in 1976. These weight ratios show that this species give a relatively quick response to the water supply; in rainier periods it develops a smaller volume of roots, which increases in the case of drought.

3. *Poa trivialis* L. stand

From the 2.5 g seed sown, 1425/m^2 seedlings came up. This mesophilous species showed a relatively slow development in the year of sowing; it was only at the end of the vegetation period that it reached a height of 23 cm and a cover of 80%. From the second year onwards various perennial and annual grass species invaded the stand *(Festuca pseudovina, Arrhenatherum elatius, Festuca pratensis, Phleum pratense, Taraxacum officinale, Trifolium repens,*

Table 4

Trend of changes in the mass of roots of perennial grasses, q/ha

Species	Sampling date	Depth of soil in cm — Weight of roots in fresh and dry matter, q/ha: 0—10 fresh	0—10 dry	10—20 fresh	10—20 dry	20—30 fresh	20—30 dry	30—40 fresh	30—40 dry	Total fresh	Total dry
1. *Agrostis alba*	7. 10. 1974	128.42	47.5	61.5	18.57	10.27	0.99	9.86	0.90	210.05	67.96
	19. 5. 1975	403.2	126.4	79.2	9.2	29.2	2.1	28.0	1.9	539.6	139.6
	15. 9. 1975	658.6	291.8	105.2	26.5	30.2	8.75	19.7	5.6	813.7	332.65
	9. 6. 1976	809.8	367.9	79.9	21.1	40.2	11.1	10.8	2.1	940.7	402.2
	10. 9. 1976	240.0	92.0	30.0	8.8	18.8	2.5	16.6	2.4	305.4	105.7
2. *Puccinellia distans*	15. 6. 1974	97.75	35.25	20.5	8.5	10.1	2.57	6.1	1.07	134.45	47.14
	7. 10. 1974	124.75	36.75	41.52	18.02	14.03	3.71	4.36	0.83	184.66	59.31
	19. 5. 1975	370.6	102.0	86.2	14.4	45.2	7.5	27.4	3.1	529.4	127.0
	16. 9. 1975	347.6	90.5	46.4	12.4	37.4	7.6	11.6	1.7	443.0	112.2
	9. 6. 1976	549.0	195.3	119.0	36.3	74.3	18.5	47.5	11.0	789.8	261.1
	16. 9. 1976	262.8	135.0	37.3	15.8	7.3	1.6	3.3	1.1	310.7	153.5
3. *Poa trivialis*	7. 10. 1974	134.5	47.2	30.4	11.1	7.27	1.4	4.72	0.35	176.89	60.05
	19. 5. 1975	595.1	161.5	52.3	8.9	27.6	3.8	0.37	0.03	675.37	274.5
	16. 9. 1975	357.4	105.2	31.0	7.9	18.5	2.8	12.0	0.7	418.9	116.6
	9. 6. 1976	244.5	104.6	20.5	5.5	14.4	2.9	7.8	0.8	287.2	113.3
	16. 9. 1976	1240.0	510.5	54.8	20.8	31.3	12.5	8.5	3.5	1334.6	548.3
4. *Alopecurus pratensis*	7. 10. 1974	213.9	71.05	36.55	13.1	21.24	6.53	3.81	0.41	275.5	91.09
	19. 5. 1975	546.3	232.2	96.4	14.3	62.4	7.0	27.1	3.3	732.2	256.8
	16. 9. 1975	741.2	292.2	86.0	27.1	78.0	27.0	14.0	1.7	919.2	348.0
	9. 6. 1976	1279.0	426.6	127.5	40.1	101.7	33.6	44.4	17.8	1552.6	554.1
	14. 9. 1976	609.5	268.7	17.6	6.0	6.5	1.1	3.5	0.3	637.1	276.1
5. *Trisetum flavescens*	7. 10. 1974	101.25	33.57	24.77	7.42	5.46	0.99	0.45	0.11	131.93	42.09
	19. 5. 1975	369.8	100.7	51.2	4.5	20.6	2.5	8.6	0.9	450.2	108.6
	16. 9. 1975	985.9	457.1	82.3	26.8	48.5	12.1	4.0	1.3	1120.7	497.3
	9. 6. 1976	1145.4	617.0	77.8	26.2	21.3	4.8	2.0	0.4	1246.5	648.4
	16. 9. 1976	470.0	199.8	40.0	8.8	13.8	2.3	8.8	1.2	532.6	212.1
6. *Festuca rubra*	7. 10. 1974	194.72	65.85	40.67	9.32	8.31	1.46	3.88	0.88	247.58	77.49
	19. 5. 1975	481.5	183.9	92.6	17.7	40.8	2.7	24.5	2.2	639.4	206.5
	16. 9. 1975	1870.3	1080.7	166.1	46.2	75.8	22.5	35.5	5.1	2147.7	1154.5
	9. 6. 1976	1653.5	866.6	142.1	45.4	48.6	10.2	15.8	6.0	1860.0	928.2
	14. 9. 1976	1171.5	630.3	73.8	33.5	19.5	8.0	9.5	2.6	1274.3	674.4
7. *Festuca pratensis*	15. 6. 1974	199.0	60.5	78.75	23.0	29.66	4.62	7.05	1.64	314.46	88.76
	7. 10. 1974	127.0	42.52	34.5	20.87	10.8	3.47	2.82	0.07	175.12	66.93
	19. 5. 1975	559.8	164.8	101.3	22.3	81.4	16.1	19.4	2.5	761.9	205.7

	16. 9. 1975	1046.2	351.3	119.7	44.5	85.3	23.2	22.3	0.47	1273.5	419.47
	9. 6. 1976	1022.7	367.7	100.2	27.9	48.7	9.9	23.5	6.5	1195.1	412.0
	16. 9. 1976	853.3	383.2	43.3	10.7	27.5	10.2	13.2	5.0	937.3	309.1
8. *Festuca arundinacea*	15. 6. 1974	199.25	67.5	66.75	23.5	22.34	5.0	13.67	3.27	302.01	99.27
	7. 10. 1974	291.25	68.6	58.92	16.3	25.31	5.29	16.07	3.51	391.55	93.7
	19. 5. 1975	498.1	123.4	94.3	15.7	57.7	8.4	35.2	5.5	685.3	153.0
	16. 9. 1975	730.5	214.3	68.3	16.0	65.5	15.8	41.6	10.6	905.9	256.7
	19. 6. 1976	1625.0	674.8	74.9	16.8	51.7	10.9	25.9	6.4	1777.5	708.9
	14. 9. 1976	1238.7	742.8	72.5	32.3	35.3	13.5	16.5	6.4	1363.0	795.0
9. *Arrhenatherum elatius*	19. 5. 1975	329.1	96.8	83.3	27.9	49.1	12.6	18.5	5.12	480.0	142.42
	15. 9. 1975	232.2	68.3	150.8	50.3	39.0	10.8	14.8	4.1	436.8	133.5
	9. 6. 1976	793.5	304.4	76.0	22.3	27.1	6.4	13.5	3.8	910.1	336.9
	16. 9. 1976	1727.6	592.7	74.5	18.0	62.0	10.0	20.0	9.3	1884.1	630.0
10. *Lolium perenne*	15. 6. 1974	253.0	84.75	69.5	21.25	28.23	4.53	9.87	1.84	360.67	112.37
	7. 10. 1974	294.75	95.67	25.67	10.57	20.22	9.44	9.23	2.29	349.87	117.97
	19. 5. 1975	445.6	131.0	61.4	9.7	51.4	6.4	18.0	2.6	576.4	149.7
	15. 9. 1975	611.1	166.5	81.8	31.6	48.2	19.8	22.0	4.8	763.1	222.7
	19. 6. 1976	469.6	166.5	83.4	23.6	48.4	12.1	24.9	5.9	626.3	208.1
	16. 9. 1976	607.5	310.5	31.3	13.5	19.8	9.8	4.8	0.5	663.4	334.3
11. *Poa pratensis angustifolia*	19. 5. 1975	521.8	188.0	34.3	11.2	19.7	5.9	8.3	1.7	584.1	206.8
	16. 9. 1975	589.6	253.3	47.7	13.3	40.0	9.8	14.1	4.0	691.4	280.4
	9. 5. 1976	503.4	180.5	51.8	16.8	39.8	12.1	14.6	3.0	609.6	212.4
	16. 9. 1976	149.28	59.68	20.3	5.8	11.5	3.0	2.5	1.8	183.58	70.28
12. *Bromus inermis*	15. 6. 1974	196.0	68.75	90.5	29.75	37.2	12.2	17.2	5.6	340.9	116.3
	7. 10. 1974	412.4	133.25	45.54	23.02	41.6	21.0	9.3	4.7	508.84	181.97
	19. 5. 1975	402.5	81.8	130.7	17.4	89.4	10.3	43.6	4.1	666.2	113.6
	16. 9. 1975	1226.5	534.3	142.5	42.5	139.5	35.5	31.2	7.2	1539.7	619.5
	9. 6. 1976	1069.2	518.9	109.6	33.4	86.7	22.6	33.0	5.8	1296.6	580.7
	16. 9. 1976	572.5	239.3	38.8	15.0	19.0	6.2	8.5	1.5	638.8	262.0
13. *Bromus erectus*	7. 10. 1974	347.6	136.54	16.8	5.72	14.6	3.32	4.8	1.1	383.8	146.68
	19. 5. 1975	360.6	88.6	62.0	11.3	42.0	9.0	20.0	3.5	484.6	112.4
	16. 9. 1975	156.1	33.5	22.0	7.1	20.2	4.7	4.85	0.9	203.15	46.2
	9. 6. 1976	433.0	125.7	48.0	7.6	23.9	3.7	14.7	2.4	519.6	139.4
	14. 9. 1976	725.0	420.3	33.8	17.0	31.3	14.8	8.8	3.1	798.9	455.2
14. *Festuca pseudovina*	7. 10. 1974	203.05	64.0	41.1	13.1	13.52	2.23	6.37	1.58	264.04	80.91
	19. 5. 1975	361.4	100.5	112.9	21.9	60.7	10.8	26.9	2.0	561.9	135.2
	16. 9. 1975	1389.7	782.0	206.5	58.8	94.3	25.6	45.4	18.2	1735.9	884.6
	9. 6. 1976	1452.4	724.2	154.8	58.1	92.1	19.1	19.3	4.2	1718.6	805.6
	14. 9. 1976	1602.5	941.0	84.2	47.0	39.3	16.8	15.8	5.0	1741.8	1009.8
15. *Festuca sulcata*	7. 10. 1974	200.0	75.5	42.4	13.75	35.0	9.46	19.01	7.0	296.41	105.71
	19. 5. 1975	650.5	317.4	115.8	24.8	62.4	10.1	18.7	2.7	847.4	355.0
	16. 9. 1975	1731.1	958.8	71.9	19.7	45.5	18.5	24.7	9.2	1873.2	1006.2
	9. 6. 1976	2087.3	1267.3	137.3	48.7	71.9	29.8	33.0	12.1	2329.5	1357.9
	14. 9. 1976	2450.0	1321.0	69.3	30.0	25.0	7.5	17.3	5.3	2561.6	1363.8

Erigeron canadensis, Setaria viridis) and made up 5—10% of the total cover. Dry matter production showed a steady increase right from the first year (48 q/ha—56.5 q/ha) (Table 3). A similar rising tendency was observed in the development of the root system, except for the destruction of the roots in 1976 due to drought. The weight ratio of dry grass crop to root mass at successive cuttings was 1 : 1.2 in 1974, 1 : 8.5 and 1 : 6 in 1975, and 1 : 3 and 1 : 32 in 1976. Of the root mass 90—93% was found in the 0—10 cm layer of soil. The root system of this species was also highly responsive to changes in the water supply (Table 4).

4. *Alopecurus pratensis* L. stand

From the 1.25 g/m^2 seed 1175/m^2 seedlings developed. It was only at the end of the first year that this vigorously tillering mesophilous grass reached an average height of 25—30 cm and an 80% cover. From the second year on the species sown gave a fairly constant cover of 50—60%, while the proportion of alien species *(Festuca pratensis, Festuca arundinacea, Lolium perenne, Taraxacum officinale, Reseda lutea, Erigeron canadensis, Setaria viridis, Amaranthus retroflexus)* was about 30—35%. The largest grass yield (78.25 q/ha dry matter) was attained by the stand in the year of sowing; in the second and third year production assumed a steady level of 48 q/ha. In 1975 the yields of the two growths were almost identical; in 1976 the second crop weighed not much more than half the first one, which could be attributed to the drought (Table 3). The weight of the dry root mass in the 0—40 cm layer of soil increased threefold in the second and third year compared to the results obtained in the autumn of the first year, and 97% of the roots were found in the 0—10 cm soil layer compared to 78% in the first year (Table 4). The weight ratio of dry matter between the aboveground and belowground plant parts at the test cuttings was 1 : 1.2 in 1974, 1 : 11 and 1 : 14 in 1975, and 1 : 20 and 1 : 13 in 1976. This mesophilous species develops a voluminous root system when grown under arid site conditions and responds sensitively to the seasonal amounts of precipitation.

5. *Trisetum flavescens* (L.) Beauv. stand

From the 1.25 g seed sown, 2200/m^2 seedlings came up. This perennial mesophilous grass of loose growth habit developed slowly and only attained an average height of 25—30 cm and a cover of 80% at the end of the vegetation period. In 1975 the share of the species sown was 99% and that of alien species 1%. In 1976 the species sown covered 70% of the area and the intruder species *(Festuca pseudovina, Agrostis alba, Taraxacum officinale, Hibiscus trionum, Setaria viridis, Erigeron canadensis)* 30%. The dry weight of the crop was 22.75 q/ha in the first year, 49.17 q/ha in the second and 42 q/ha in the third year (Table 3). The weight of dry root mass from the 0—40 cm layer of soil increased constantly until the middle of the third year; by autumn, however, it was sharply reduced because of drought. In the third year 95% of the roots were concentrated in the 0—10 cm layer of soil compared to 80% in the first year (Table 4). The weight ratio of dry aboveground to belowground plant parts was 1 : 1.8 in the autumn of 1974, 1 : 5.4 and 1 : 18 in 1975, and 1 : 36 and 1 : 9 in 1976. The root system is highly responsive to changes in the amount of precipitation in this species too.

6. *Festuca rubra* L. stand

From 5 g seed 2750/m^2 seedlings were obtained. This perennial mesophilous undergrowth only formed a stand and reached an average height of 15—20 cm and a 90% cover at the end of the vegetation period. In the second year the stand became completely closed (100% cover). By the autumn of the third year alien species *(Festuca arundinacea, Erigeron canadensis, Convolvulus arvensis, Hibiscus trionum)* had a share of 3—5%. The stand produced the largest dry matter yield in the second year (59.5 q/ha); in the third year this decreased by 7 q/ha. The second crop was always considerably larger than the first (Table 3). The trend of root development was similar to that of the yield. Of the dry root mass 93% was concentrated in the 0—10 cm layer of soil in samples taken in the third year, compared to 85% in the first year. The weight ratio of dry aboveground to belowground plant parts at test cutting was 1 : 18 in 1974, 1 : 8.5 and 1 : 33 in 1975 and 1 : 54 and 1 : 19 in 1976, which demonstrates the high responsiveness to changes in the water supply in this mesophilous species when grown under arid conditions (Table 4).

7. *Festuca pratensis* Huds. stand

From the 5 g seed sown, 4475/m^2 seedlings developed. This vigorously sprouting mesophilous species formed a pure single-species closed grass stand with 100% cover in the very first year, which was maintained throughout the whole period of the experiment. The totalled results of two cuts per year show that the largest yield (115 q/ha dry matter) was obtained in the vegetation period of the first year; from then on the size of the grass crop gradually decreased until the autumn of the third year (75 q/ha) (Table 3). The weight of the roots in the 0—40 cm layer of soil increased till the autumn of the second year, then, parallel to the gradual concentration of the mass of roots in the top soil, substantially decreased (66—91%) (Table 4). The weight ratio of dry matter between the aboveground and belowground plant parts was 1 : 2 and 1 : 1 in 1974, 1 : 4.5 and 1 : 9.3 in 1975, and 1 : 7 and 1 : 13 in 1976 at the dates of test cutting. When grown under arid conditions this mesophilous species responds to changing amounts of precipitation with a considerable fluctuation in root volume.

8. *Festuca arundinacea* Schreb. stand

From the 5 g amount of seed sown, 2800/m^2 seedlings came up. This energetically developing and tillering mesophilous grass attained a 100% cover in the year of sowing, which was maintained throughout the period of the experiment. The share of alien species *(Erigeron canadensis, Echinochloa crus-galli)* was negligible (0.1%). The largest dry matter yield (110 q/ha) was obtained in the second year after sowing, which dropped to half (64 q/ha) in the growth season of the third year as a result of drought, while the structure of the stand was maintained (Table 3). The tendency of root growth was similar to that of the crop, i.e. the weight of the roots reached a maximum by the autumn of the second year, then fell to one-third in the third year. The gradual concentration of the bulk of the roots in the 0—10 cm layer of soil, from 68% in the first to 95% in the third year, and its decrease to 60% at the time of the 1976 drought can again be observed (Table 4). The weight ratio of dry aboveground and belowground plant parts at the dates of test cutting was 1 : 2.75 and 1 : 1.5 in 1974, 1 : 3 and 1 : 4 in 1975, and 1 : 23 and 1 : 23 in 1976. The great difference in the 1976 fugures indicates the high adaptability of this mesophilous species, which compensates for a lasting water deficiency by the rapid development of its root system.

9. *Arrhenatherum elatius* (L.) J. et C. stand

From 5 g seed 450/m^2 seedlings were obtained. This perennial mesophilous grass, which grows in thin clumps, developed poorly in the year of planting, hardly attaining a 25% cover, so the yield was not studied in the first year. As a result of tillering the stand reached a 50% cover in the second and a 75% cover by the autumn of the third year. The share of alien species *(Festuca sulcata, F. rubra, F. arundinacea, F. pseudovina, Erigeron canadensis, Hibiscus trionum, Trifolium arvense, Matricaria inodora, Setaria viridis, Taraxacum officinale)* was reduced from 22% in the first year to 15%. As the grass stand gradually closed the dry matter yield of the second year (41 q/ha) was doubled in the third year (91 q/ha) in spite of the unfavourable climatic conditions (Table 3). The weight of the dry root mass from the 0—40 cm layer of soil was less in the third year than in the second year. In the autumn of the third year 94% of the roots were concentrated in the 0—10 cm soil layer compared to 87% in the spring of the second year (Table 4). The dry weight ratio of aboveground to belowground plant parts at cutting was 1 : 9 and 1 : 6 in 1975, and 1 : 5.5 and 1 : 17 in 1976. This mesophilous species also responds to insufficient precipitation by increasing the volume of its root system.

10. *Lolium perenne* L. stand

From the 5 g seed sown, 9625/m² seedlings were obtained. This short-rhizomed mesophilous perennial grass, which grows in thin bushes, formed a completely closed pure grass stand with 95% cover in the year of sowing, which remained unchanged throughout the vegetation period of the second year. In the third year, parallel to the thinning of the stand, the proportion of alien species *(Festuca arundinacea, Cynodon dactylon, Setaria glauca, Erigeron canadensis, Convolvulus arvensis, Taraxacum officinale, Amaranthus retroflexus)* increased to 10%. The largest dry matter yield was produced by the grass stand in the year of planting (110 q/ha), dropping to half (59 q/ha) in the second year. The two cuts in the third year resulted in no more than two-thirds of this (45 q/ha). Of the successive growths the second crop was the largest except in the first year (Table 3). The weight of the roots in the 0—40 cm layer of soil showed a trend similar to that of the crop. The decrease in the phytoproduction of the grass stand can primarily be explained by the compaction of the soil, the concentration of the root system near the soil surface, and the peculiar ecological conditions of the site (Table 4). The dry weight ratio between aboveground and belowground plant parts at cutting was 1 : 3.4 and 1 : 1.5 in 1974, 1 : 2 and 1 : 7 in 1975, and 1 : 8 and 1 : 17 in 1976; the latter can be attributed to the high adaptability of the species under droughty conditions.

11. *Poa pratensis* L. ssp. *angustifolia* Gaud. stand

From 5 g/m² seed 110 seedlings came up. This perennial, rhizomic, meso-xerophilous undergrowth, which produces thin bushes, developed slowly in the year of planting and did not form a closed stand, so the phytoproduction was not recorded that year. By the autumn of the second year after sowing an 80% cover was reached and this was maintained throughout the vegetation period of the third year. In the meantime the proportion of alien species *(Festuca pratensis, F. sulcata, F. arundinacea, Setaria glauca, S. viridis, Echinochloa crus-galli, Medicago falcata, Erigeron canadensis, Convolvulus arvensis, Achillea collina, Taraxacum officinale, Portulaca oleracea, Amaranthus retroflexus, Capsella bursa-pastoris)* dropped from 30 to 20%. In the second year after plantation the dry matter yield of the two growths was 32 q/ha, which rose the following year to 40 q/ha (Table 3). The weight of root mass in the 0—40 cm layer of soil substantially decreased in the third year in consequence of unfavourable precipitation conditions. The dry weight ratio of aboveground to belowground plant parts at the time of cutting was 1 : 10 and 1 : 13 in 1975 and 1 : 10 and 1 : 3.5 in 1976. The latter suggests a high rate of root destruction, because this species did not increase the volume of its root system to counterbalance water losses caused by drought in the aboveground plant parts (Table 4).

12. *Bromus inermis* Leyss. stand

From 2.5 g/m² seed 2225 seedlings were obtained. This perennial, rhizomic, xerophilous top grass formed a completely closed stand with 100% cover, free from alien species in the year of sowing. The largest dry matter yield (77.5 q/ha) was obtained in the second year, compared to 65 q/ha in the first and 52 q/ha in the third year. The second crop was always larger than the first, except for the autumn growth after the dry summer of 1976 (Table 3). The trend of root development in the 0—40 cm layer of soil agreed with that of the aboveground plant parts. As a consequence of the 1976 drought nearly 50% of the root system was destroyed after two years of steady weight increase (Table 4). The dry weight ratio between aboveground and belowground plant parts at the time of cutting was 1 : 4.5 and 1 : 4.5 in 1974, 1 : 3 and 1 : 16 in 1975, and 1 : 21 and 1 : 10 in 1976, which can be explained by the arid ecological conditions and the xerophilous nature of the species.

13. *Bromus erectus* Huds. stand

From 5 g/m^2 seed 650 seedlings developed. This perennial meso-xerophilous top grass, growing in thin bushes, did not form a stand until the autumn of 1974, with a 70% cover. Later the stand became completely closed and reached a cover of 100%, in which the proportion of alien, intruder varieties *(Lolium perenne, Festuca pseudovina, F. pratensis, Bromus mollis, Echinochloa crus-galli, Setaria glauca, Erigeron canadensis, Amaranthus albus, Taraxacum officinale, Convolvulus arvensis, Polygonum aviculare, Capsella bursa-pastoris)* was 20—30%. The production of the grass stand steadily increased during the period of the experiment, despite the drought in the third year. The dry matter yields weighed in the successive years were 17, 35 and 45 q/ha, respectively (Table 3). The second crop was always larger than the first. The volume of roots in the 0—40 cm layer of soil showed a gradual increase in weight, reaching a maximum in the period of drought (Table 4). The dry weight ratio of aboveground to belowground plant parts at the time of cutting was 1 : 10 in 1974, 1 : 12 and 1 : 2 in 1975, and 1 : 8 and 1 : 17 in 1976. These extremely variable ratios show that the root system of this species is very sensitive to the water supply, i.e. it responds to an abundant water supply with a sudden reduction of the root system, while in the case of drought, like most xerophilous species, the root system increases considerably.

14. *Festuca pseudovina* Hack. stand

From 2.5 g/m^2 seed 4375 seedlings were obtained. This xerophilous undergrowth, which produces thick bushes, formed a completely closed, pure stand with 100% cover by the end of the vegetation period. Alien species did not appear in the stand until the third year after sowing *(Festuca arundinacea, Agropyron repens, Lolium perenne, Trifolium repens, Convolvulus arvensis)*, and even then they only represented 0.5%. The dry matter production of the stand was almost the same (about 30 q/ha) on average for the three years (Table 3). The volume of roots in the 0—40 cm layer of soil, on the other hand, showed an intensive growth using the period of the experiment and a gradual concentration in the 0—10 cm soil layer, reaching a maximum in the dry period; the weight of the root mass was then nearly twelve times larger than in the autumn of the first year (Table 4). The dry weight ratio of aboveground to belowground plant parts at the time of cutting was 1 : 2.5 in 1974, 1 : 8 and 1 : 49 in 1975, and 1 : 53 and 1 : 72 in 1976. This great difference between the aboveground and belowground plant parts proves the xerophilous character of the species under arid site conditions.

15. *Festuca sulcata* (Hack.) Nym. stand

From 2.5 g/m^2 seed 1400 seedlings were obtained. This thick, typically xerophilous undergrowth formed a pure, single-species stand with 100% cover by the autumn of the year of sowing. In the autumn of the third year the proportion of alien species (*Festuca pratensis, Bromus inermis, Lolium perenne, Echinochloa crus-galli, Convolvulus arvensis, Erigeron cana-*

densis) in the stand was 2%. The dry matter yield of the single growth in the first year was 42 q/ha, while that of the two growths in the second year was 33 q/ha. In the third year the yield was doubled and reached 67 q/ha in spite of the unfavourable precipitation conditions (Table 3). The weight of the root mass in the 0—40 cm layer of soil showed a steady increase during the period of the experiment. In the autumn of the third year the dry weight of the roots was twelve times as large as in the autumn of the first year, and during the three years of the experiment the roots gradually concentrated in the upper soil layer near the surface of the ground. The dry weight ratio of aboveground to belowground plant parts at the time of cutting was 1 : 2.5 in 1974, 1 : 22 and 1 : 59 in 1975, and 1 : 30 and 1 : 59 in 1976. Comparing the autumn ratios in the last two years it can be seen that both an abundant water supply and a dry period resulted in a rapid increase in the volume of roots in this drought-tolerant species.

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EFFECT OF LEAF AREA REDUCTION ON STANDABILITY AND PREMATURE DEATH OF LEAVES IN MAIZE (ZEA MAYS L.) HYBRIDS WITH DIFFERENT GENOTYPES

Under unfavourable ecological conditions or under stress causing the reduction of the leaf area (e.g. hail) there is often a considerable increase in the premature death of leaves and in the lodging percentage, an indicator of poor standability, compared to the normal conditions.

Factors influencing the standability were studied by Koehler *et al.* (1925) and Nelson (1958), who gave stalk rot as a reason for stem breaking. Zuber—Grogan (1961) and Loesh *et al.* (1963) consider the mechanical strength, including the thickness of the rind, to be an important determinant of standability. Kálmán *et al.* (1974) found a close correlation between the mechanical strength of the stalk and the state of health of the pith.

The relationship between the reduction of the leaf area and the health condition of the pith of the stalk was studied by Holbert *et al.* (1935), DeTurk (1937), Michaelson (1957) and Koehler (1960). According to their observations the infection of the stalk increased considerably after defoliation carried out at the time of flowering.

On the basis of several years of investigation Thompson (1963) and Zuber—Loesh (1966) pointed out that the thickness of the rind, like other mechanical properties, was determined by the genotype and less responsive to ecological factors than the health condition of the medulla.

The premature death of leaves was observed by Jugenheimer (1940), Hoadley (1942), Michaelson (1957), Aldrich—Leng (1972) and Aldrich *et al.* (1975). A close correlation was found between the premature death of leaves and the infection of the pith of the stalk by Diplodia zeae and Gibberella zeae. According to the explanation of Littlefield—Wilcoxson (1962) and Korom *et al.* (1975) the phenomenon is caused by the fact that in consequence of the infection the vascular bundles in the stalk which transport the water and nutrients, get blocked. Littlefield *et al.* (1962) pointed out a reduction in yield when the necrotic lesions causing the blocking of the vascular bundles covered more than 50% of the surface of the pith.

In the course of our investigations we tried to find out how the standability and the premature death of leaves in hybrids with different genotypes would change as a response to various extents of defoliation.

In the experiment hybrids with various genotypes, vegetation periods and FAO numbers, produced and maintained at the Cereal Research Institute, Szeged, and commercially produced in Hungary were used as experimental stock (Table 1). The genetic composition of the hybrids in the order followed in the table was: 1. (GK71 × GK72) × 153R, 2. (GK1 × GK3) (GK2 × W37A), 3. A90 × 153R, 4. 153R × Szv 293, 5. (GK73 × C22) (W64A × WF9), 6. A632 × × 153R-base, 7. (A632 × GK17) × GK13, 8. Oh43/K × A632.

The experiment was carried out in 1976 and 1977 at the Ságvári station of the research institute, Szeged (at a latitude of 46°N in the temperate zone). At the time of female flowering the leaves were removed in each hybrid to various extents, so that the following treatments were obtained: 1. all leaves left on the plant (control), 2. only leaves above the main ear left, 3. only half the leaves above the main ear left, 4. all leaves removed. Total defoliation was only carried out in 1977. The treatments in 1976 included 15 plants per plot without replication; in 1977 there were 12 plants per plot in 3 replications, i.e. a total of 36 plants, arranged in a random block design.

Sowing was carried out both years to a plant density of 6 plants/m^2 in rows spaced at 70 cm. The lodging percentage was determined on harvesting (at 30% water content in the grain) by the proportion of plants broken below the main ear. On harvesting the stalk was cut off at the second internode above the ground and the surface thus obtained was evaluated on the following scale: 3 = healthy, 2 = moderately infected, 1 = highly infected.

Table 1

Changes in the lodging percentage as a response to leaf area reduction

Hybrid	Total leaves		Only leaves above the main ear left		Only half the leaves above the main ear left		No leaves left	Increase	
	1976	1977	1976	1977	1976	1977	1977	1976	1977
1. Sze TC 255	3.2	8.3	20.0	25.0*	33.3	52.7***	2.7	16.8	16.7
2. Sze DC 289	2.8	5.5	32.0*	38.8***	46.7***	61.1***	0.1	29.2	33.3
3. K SC 360	0.1	0.1	13.3	8.3	26.7*	44.4***	0.2	13.2	8.2
4. Sze SC 369	0.2	0.3	0.3	11.1	6.6	30.6***	5.5	0.1	10.8
5. Sze DC 384	1.6	2.7	46.7*	36.1***	53.0***	63.9***	5.5	45.1	33.4
6. Bc 418	0.3	0.2	6.7	8.3	20.0	36.1***	11.1	6.4	8.1
7. Sze MSC 515	—	0.2	—	38.8***	—	33.3***	2.7	—	36.1
8. Sze SC 565	—	0.2	—	19.1*	—	63.9***	0.1	—	18.9
$LSD_{5\%}$	ns	ns	26.0	19.0	28.0	23.0	8.0	—	—
$LSD_{1\%}$	ns	ns	35.0	25.0	38.0	30.0	11.0	—	—

Note:
- By "increase" the increase in lodging percentage caused by the removal of the leaves below the ear as compared to the control treatment (total leaves) is meant.
- The significance of the differences among the different treatments compared to the control (total leaves) in each hybrid is shown by * = $P_{5\%}$, *** = $P_{1\%}$. Within the same treatment the significance of the differences among hybrids was determined using the $LSD_{5\%}$ or $LSD_{1\%}$ values. ns = no significant difference.

The thickness of the rind was measured in the following way. On harvesting a sample was taken from the rind of the 2nd internode of each plant. The samples were dried for 2 weeks at 40 °C, then cleaned of the medulla and measured for thickness in micrometers.

The premature death of the leaves can easily be distinguished from the withering of leaves caused by natural maturing or a shortage of water or nutrients on the basis of the discolouration of the leaves. In the latter case the leaf withers and falls off after a reddish or yellowish discolouration which starts from various points of the leaf, depending on the origin of the withering. In the case of the premature death of leaves, on the other hand, the green leaf becomes lead-coloured. The premature death of the leaves was characterized by the water content of the grains, estimated when the leaves withered. Parallel with the experiment a complementary plot was sown from each hybrid where defoliation was not carried out, so that the leaf area of the plants agreed with that of the control. From the time when the grains contained 40—42% water until harvesting (at 30% grain water content) the water content of the grains in the complementary plots was measured every 6 days. From the first occasion when the water content was measured each plant in the experiment was examined every second day, and for those showing a premature death of the leaves the date of withering and excision was recorded. The water content at the time of the premature death of the leaves was thus determined for each plant on the basis of the water contents found every 6 days in the complementary plots and the rate of daily water loss, as well as by the time of the premature death of the leaves. If the leaves of a plant were green or showed natural withering at the time of harvesting, in order to facilitate the evaluation of the experiment the water content of the grain at the "premature death of the leaves" was uniformly taken as 20%, and the correlation between the thousand-grain-weight and the premature death of the leaves was determined only for those hybrids for which data from both years were available.

The data were surveyed and evaluated for each plant separately. Correlation coefficients between the lodging percentages of the two years were calculated for each hybrid. The reproducibility of the tendency concerning the reactions was characterized by the value of the correlation.

The coefficients of correlation between the lodging percentage of the hybrids in the two years were $r = 0.9792^{****}$ for the total leaves, $r = 0.888^{**}$ for leaves above the main ear and $r = 0.9864^{****}$ for half the number of leaves above the main ear (Table 1). These coefficients prove the reproducibility of the tendencies.

In agreement with earlier examinations the lodging percentage increased in each hybrid with the reduction of the leaf area in both years, except in the case of total defoliation. There are, however, substantial differences in growth between the genotypes. This is clearly shown by the last two columns of the table. The increase in the lodging percentage of the treatment representing the leaves above the main ear, as compared to the control, shows the same tendency in the two years in each hybrid, as confirmed by the coefficient of correlation ($r = 0.8978^{**}$) between the data of the two years, which also proves that the differences in lodging percentage are characteristic of the individual hybrids. This finding may provide a basis for the elaboration of a method suitable for the rapid determination of standability.

Table 2 shows the changes in the thickness of the rind and the health condition of the medulla as a response to the treatments, on the average of 8 hybrids. In agreement with earlier investigations the data unequivocally show that with the exception of total defoliation the reduction of the leaf area is accompanied by increased infection of the stalk.

The two parameters, especially when examined on the basis of two years' results, display the same tendency of change under the influence of leaf area reduction. This may lead to the wrong conclusion that infection of the stalk reduces the thickness of the rind. This is contradicted by the fact that in the total defoliation treatment the rind is significantly thinner than in the control, and there was no reliable difference concerning the health condition of the pith between the two treatments. It can thus be established that the reduction in the

Table 2

Changes in the thickness of the rind and the health condition of the medulla as a response to leaf area reduction on the average of 8 hybrids

Parameters	Total leaves	Only leaves above the main ear left	Only half the leaves above the main ear left	Total defoliation	$LSD_{5\%}$	$LSD_{1\%}$
Thickness of rind (mm)						
two-year average	1.16	1.07	1.04	—	0.082	0.110
1977 data	1.20	1.11	1.06	1.07	0.120	ns
Health condition of medulla (score 1–3)						
two-year average	2.92	2.32	2.02	—	0.194	0.259
1977 data	2.93	2.48	2.10	2.90	0.160	0.216

Note: ns = no significant difference
3 = healthy; 1 = highly infected

thickness of the rind after defoliation does not depend on the infection, but apparently occurs as a direct consequence of defoliation.

On the average of 2 years' data on 8 hybrids a non-significant correlation of $r = -0.2972$ between rind thickness and lodging percentage, and a significant correlation of $r = -0.7878^{****}$ between the health condition of the medulla and the lodging percentage were found after

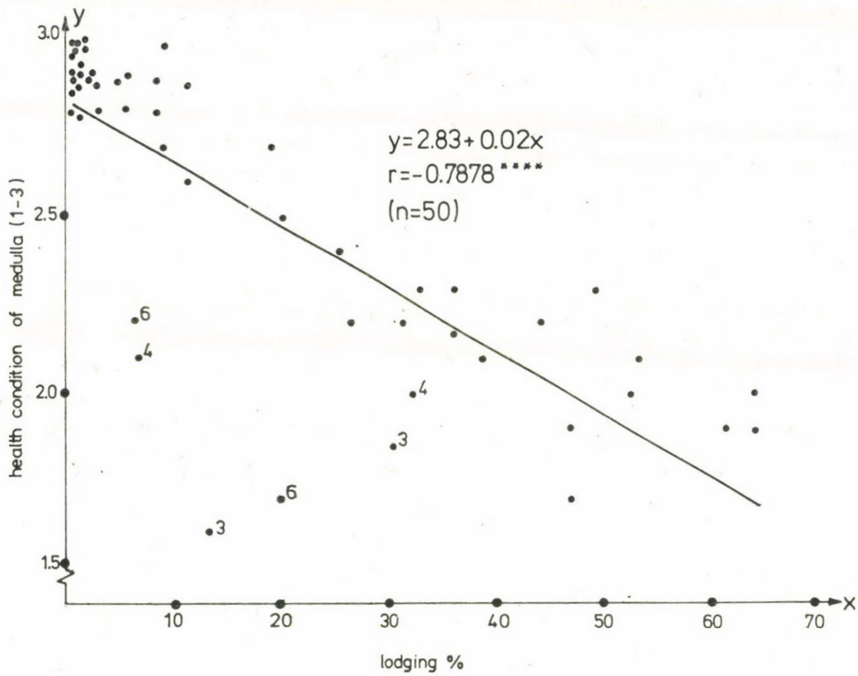

Fig. 1. Relationship between the health condition of the pith of the stalk and the percentage of lodging. (Note: The figures beside some of the data serve for the identification of the hybrids and agree with the serial numbers in Table 1)

defoliation. If the data of the total defoliation treatment is left out of consideration in the course of the evaluation the corresponding values will be $r = -0.3443^{*}$ and $r = -0.7381^{****}$, respectively.

The correlations found between the health condition of the medulla and the standability are shown in Fig. 1 for all treatments on each hybrid in both years. The partial data for some hybrids (e.g. K SC 360 = No. 3; Sze SC 369 = No. 4; Bc 418 = No. 6) considerably differ from the general correlation. This means that the treatment in question shows a relatively low deficiency in standability in spite of the infected medulla, because the mechanical strength of the rind protects the stalk from breaking. On the basis of Fig. 1 it can be established that the increased lodging percentage observed as a consequence of defoliation is related primarily with the health condition of the medulla. Changes in the lodging percentage caused by the infection of the stalk may be modified by the thickness of the rind.

According to the data in Table 3, the leaves withered and fell earlier, at a significantly higher ($P_{5\%}$ or $P_{1\%}$) grain water content, when the leaves below the main ear had been removed than in the total leaf area control. Further defoliation (removal of half the leaves above the main ear), compared to the treatment where all the leaves above the main ear were left only resulted in a significantly earlier withering of the leaves in 6 cases out of 14 observations during the two years.

The 6 hybrids examined in both years were put into order. In the total leaf area treatment Sze DC 384 gave very high values in both years, which shows that its leaves withered early compared to the other hybrids. When the leaves below the main ear were removed 3

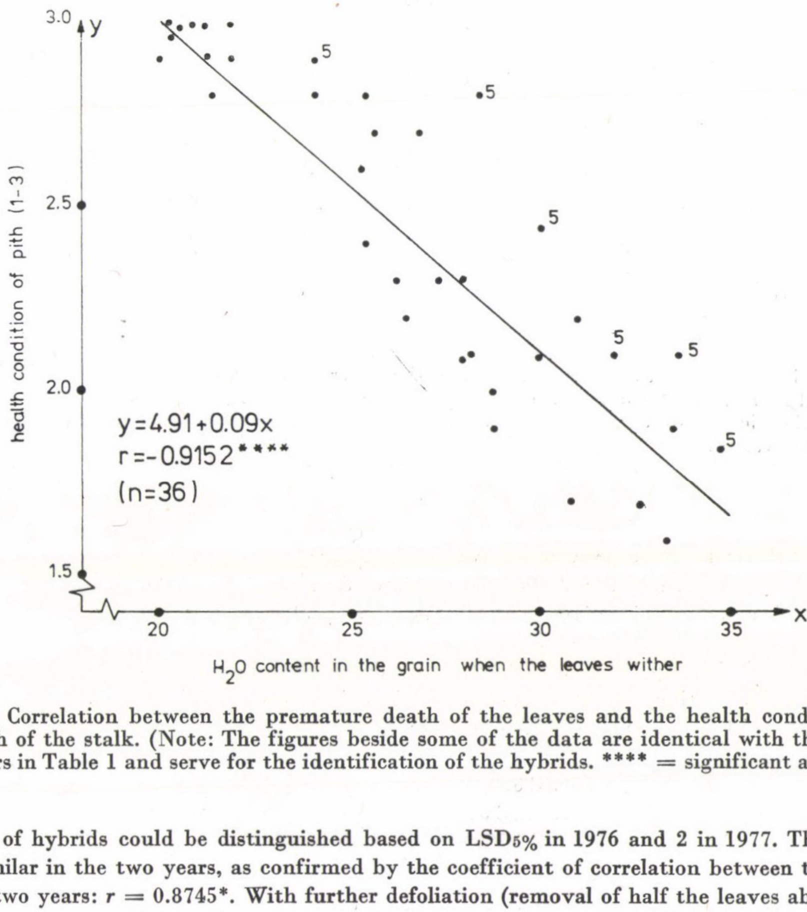

Fig. 2. Correlation between the premature death of the leaves and the health condition of the pith of the stalk. (Note: The figures beside some of the data are identical with the serial numbers in Table 1 and serve for the identification of the hybrids. **** = significant at $P_{0.1\%}$)

groups of hybrids could be distinguished based on $LSD_{5\%}$ in 1976 and 2 in 1977. The order was similar in the two years, as confirmed by the coefficient of correlation between the data of the two years: $r = 0.8745^*$. With further defoliation (removal of half the leaves above the main ear) 3 groups of hybrids could be distinguished in 1976 and 2 in 1977, as in the former treatment. The order was similar in the two years and the correlation coefficient was $r = 0.8231^*$.

It can thus be established that in maize hybrids with different genotypes the premature death of the leaves does not show the same trend after the same extent of defoliation. There are more susceptible (e.g. Sze DC 384) and less susceptible (e.g. Sze SC 369) genotypes.

The correlation between the premature death of the leaves and the health condition of the pith of the stalk is shown in Fig. 2. The close correlation between the two parameters confirms the earlier literary data. It is remarkable, however, that for Sze DC 384 (hybrid No. 5) the values for both years in all three treatments are above the straight line. This sug-

Table 3

Grain water content at the time of the premature death of the leaves caused by defoliation

Serial number	Hybrid	Total leaves		Only leaves above the main ear left		Only half the leaves above the main ear left	
		1976	1977	1976	1977	1976	1977
1.	Sze TC 255	—	21.2	—	25.3***	—	28.9***
2.	Sze DC 289	—	21.4	—	26.2***	—	28.9***
3.	K SC 360	20.9	21.9	33.4***	26.9***	32.6***	31.0***
4.	Sze SC 369	20.7	21.2	24.0*	25.2***	28.0***	26.5***
5.	Sze DC 384	27.3	24.0	34.7*	30.2***	33.7*	31.9***
6.	Bc 418	20.0	20.0	28.1***	25.4***	33.4***	27.3***
7.	Sze MSC 515	20.6	21.9	34.3***	30.0***	30.8***	27.8***
8.	Sze SC 565	20.0	20.4	27.1***	25.6***	40.3***	33.5***
	$LSD_{5\%}$	3.23	1.85	5.07	3.11	4.46	3.13
	$LSD_{1\%}$	4.29	2.44	6.73	4.09	5.92	4.12

Note:
— The significance of the differences among the different treatments compared to the control (total leaves) in each hybrid is shown by * = $P_{5\%}$, *** = $P_{1\%}$. Within the same treatment the significance of the differences among hybrids can be determined using the $LSD_{5\%}$ or $LSD_{1\%}$ values.

gests that there are genotypes whose leaves wither before the vascular bundles become blocked (as a consequence of infection). This fact incidates that besides the blocking of the vascular bundles other factors (bioactive toxic substances) may also promote the premature death of the leaves.

The relationship between the premature death of the leaves (grain water content at the time of withering) and the thousand-grain-weight was examined. Assuming a linear correlation the following values were obtained:

K SC 360	$r = -0.9555$***
Sze MSC 515	$r = -0.8688$*
Sze SC 565	$r = -0.9424$***

If the above values are compared to the data on the grain water content indicative of the intensity of leaf withering (Table 3) it can be established that the thousand-grain-weight ubstantially decreases when the leaves wither before maturity.

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EFFECT OF NITROGEN FERTILIZER AND SOME MICRO-ELEMENTS ON THE YIELD, OIL CONTENT AND VIABILITY OF COTTONSEED (GOSSYPIUM BARBADENSE L.)

The economic basis for measuring the physical and chemical properties of cottonseed considered the hull and the kernel as the product (BAILEY 1948). Micro-elements had a pronounced effect on biological characteristics. KHODZHAEV (1970) reported that some trace-elements applied alone or in combination markedly increased the photosynthetic productivity. STESNYAGINA—GIRINA (1970) showed that the foliar application of 0.01% boric acid affected the respiration and decreased the catalase activity. AGAEV (1973) indicated that the combination of different trace-elements increased the cottonseed yield. ANDERSON—WORTHINGTON (1971) and TAILAKOV—ATAEVA (1973) reported that the foliar application of B and Mn increased the cottonseed yield. ATAKOV—SULEIMANOV (1973) found that Mn or Mn + Al increased the cottonseed yield. AGAEV (1973), ANDERSON—WORTHINGTON (1971) and TAILAKOV—ATAEVA (1973) showed that the application of trace-elements increased the seed oil content, whereas the application of N fertilization increased the seed yield but the seed oil content and oil yield were decreased.

The aim of this investigation was to study the effects of nitrogen fertilization and some micro-nutrients on the yield, oil content and viability of cottonseed.

Two field experiments were conducted at the Faculty of Agricultural Science, Moshtohor, Kalubia, Egypt during the 1975 and 1976 seasons. The cotton variety Giza 69 (*Gossypium barbadense* L.) was used. The levels of nitrogen fertilizer, namely, 72 and 144 kg N/ha, represented the main plots. Every main plot was divided into 8 sub-plots and these were assigned to micro-nutrient treatments, namely, Control, B, Zn, Mn + Zn, Mn + B, Zn + B and Mn + Zn + B. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was side-dressed after thinning the plants. Each micro-nutrient alone or in combination was sprayed separately once, approximately two weeks before flowering, in the form of chelate, Na_2Mn (15% Mn) and Na_2Zn (14.2% Zn), or for B, in the form of borax ($Na_2B_4O_7 \cdot 10\ H_2O$). The concentration of each chelated substance in the solution was 0.3% (for the whole chelate). The spray volume for each substance was 1440 litres/ha (1.5 litres/sub-plot). The area of each sub-plot was 10.5 m² (3×3.5 m). The soil type was clay loam. A brief account of the chemical analysis using disturbed samples from the soil profile of the experimental sites before planting, according to the methods described by JACKSON (1958) and CHAPMAN—PRATT (1961), is presented in Table 1.

Table 1

The soil analysis for the experimental farm

Saturated soil paste				Suspension 1 : 2.5	Available			
m.eq./l				pH	N	Mn	Zn	B
K^+	N^+	Ca^{2+}	Mg^{2+}		% ppm/100 g soil			
0.83	6.53	5.75	8.87	8.1	0.068	190	5	50

The normal cultural practices for growing cotton were followed.

Cottonseed samples 200 g in weight were obtained from each sub-plot to determine the following:

1. *Physical characteristics*

A) Seed index (weight of 100 seeds in g).
B) Hull and kernel weights, which were separated using a sharp razor.
C) Hull and kernel weight/ha.

2. *Oil content*

Representative samples for hull and kernel were dried at 105 °C overnight to determine the moisture content. Samples were ground in a blender to determine the oil content according to the methods described in the A.O.A.C. (1970) recommendations.

3. *Seed viability*

Seeds were collected from each plot at random. These seed samples were tested for various seed characteristics according to the method mentioned by BUXTON—SPRENGEI (1976) to determine *a)* seed germination by counting seedlings with undamaged radicals longer than 1 cm, *b)* seedling dry weight, *c)* length of seedling.

The data were statistically analysed according to the methods outlined by SNEDECOR (1965).

Effect of nitrogen fertilization. The effect of nitrogen rates on cottonseed yield is shown in Table 2. N fertilization exerted no statistically significant effect on cottonseed yield in soil containing 0.068% available nitrogen, though the application of 144 kg N/ha increased the cottonseed yield as compared with 72 kg N/ha.

The increase in kernel and hull yield on applying 144 kg N/ha over treatments which received 72 kg N/ha was 128.52 and 10.68 kg/ha respectively (Table 1). The differences between the means were significant except for that of hull yield. The increase in cottonseed yield as a result of N fertilization might be due to enhanced meristemic productivity.

The application of 144 kg N/ha significantly increased the cottonseed index (Table 2).

Table 2

Average cottonseed yield and some physical characteristics as affected by nitrogen rates

N, kg/ha	Cottonseed yield, kg/ha	Seed parts				Seed index g/100 seeds
		Kernel		Hull		
		g/seed	kg/ha	g/seed	kg/ha	
72	2001.60	0.055	1251.00	0.033	750.60	8.84
144	2140.80	0.060	1379.52	0.033	761.28	9.32
LSD (0.05)	N.S.	0.0026	—	N.S.	—	0.39

The results in Table 3 indicate that increasing N rates had no significant effect on cottonseed viability.

Table 3

Average cottonseed viability as affected by nitrogen rates

N, kg/ha	Germination, %	Dry weight g/100 seedlings	Length of seedling, cm
72	84.97	0.32	11.54
144	84.41	0.29	11.49
LSD (0.05)	N.S.	N.S.	N.S.

The effect of N fertilization on oil cottonseed content is shown in Table 4. Adding 144 kg N/ha decreased the percentage oil content of the kernel, hull and total seed as compared with treatments fertilized with 72 kg N/ha. These results might be attributed to an increase in amino acid formation in seed fertilized with N fertilizer, which requires large amounts of carbohydrate. These results are in good agreement with those obtained by AGAEV (1973), ANDERSON—WORTHINGTON (1973) and TAILAKOV—ATAEVA (1973). The oil cottonseed yield/ha increased with increasing rates of nitrogen fertilization. The increase in oil yield/ha was due to an increase in seed yield/ha after high N fertilization.

Effect of micro-nutrients. The results in Table 5 show the effect of a foliar spray of micro-elements alone or in combination on cottonseed yield and its components, i.e. kernel

Table 4

Average cottonseed oil content as affected by nitrogen rates

N, kg/ha	Kernel, %	Hull, %	Total seed, %	Oil yield, kg/ha
72	34.53	1.11	35.64	703.75
144	33.23	1.02	34.25	733.22

and hull. The foliar spraying of micro-elements alone or in combination increased the cottonseed yield/ha (AGAEV 1973, ANDERSON—WORTHINGTON 1971, TAILAKOV—ATAEVA 1973) though the differences between the means were not significant.

Micro-nutrients significantly increased the weight of kernel seed (Table 5). Spraying Zn or Mn alone significantly increased the seed weight. These results might be attributed to an increase in photosynthetic productivity (KHODZHAEV 1970). These results agree with those obtained by ANDERSON—WORTHINGTON (1971) and TAILAKOV—ATAEVA (1973).

It is noteworthy to mention that the foliar spraying of Zn + B reduced the hull seed weight (Table 5). These results attributed to the effect of these micro-elements on the indole acetic acid oxidase system (MORGAN *et al.* 1966).

Table 5

Average cottonseed yield and some physical characteristics as affected by micro-nutrients

Micro-elements	Cottonseed yield, kg/ha	Seed parts				Seed index g/100 seeds
		Kernel		Hull		
		g/seed	kg/ha	g/seed	kg/ha	
Control	2028.00	0.052	1242.55	0.033	785.45	8.53
B	2050.56	0.059	1288.78	0.035	761.78	9.43
Zn	2085.12	0.061	1350.74	0.033	734.38	9.35
Mn + Zn	2082.24	0.058	1310.98	0.034	771.26	9.17
Mn + B	2059.20	0.055	1256.11	0.035	803.09	8.83
Zn + B	2188.80	0.055	1399.73	0.031	789.12	8.58
Mn + Zn × B	2113.92	0.058	1347.41	0.033	766.51	8.75
LSD (0.05)	N.S.	0.0041	—	N.S.	—	0.80

Spraying micro-elements alone or in combination increased the seed index; the differences between the means were significant at the 5% level.

The effect of micro-nutrients on cottonseed viability is shown in Table 6. The foliar spraying of micro-nutrients had no significant effect on cottonseed germination or its dry weight, wh le spraying Zn or Mn + B on cotton plants two weeks before flowering significantly increased the length of the seedlings. On the other hand, a combination of micro-nutrients, encouraged the size or number of cell formation, while others reduced the size or number of seedling cells.

Table 6

Average cottonseed viability as affected by micro-nutrients

Micro-elements	Germination, %	Dry weight g/10 seedlings	Length of seedling, cm
Control	84.00	0.29	11.28
B	85.00	0.30	11.91
Zn	86.25	0.28	13.13
Mn	83.50	0.35	12.50
Mn + Zn	83.50	0.32	10.29
Mn + B	86.25	0.30	12.62
Zn + B	85.25	0.30	11.96
Mn + Zn + B	83.75	0.29	10.01
LSD (0.05)	N.S.	N.S.	1.25

The results in Table 7 indicate that the cottonseed oil content increased in the kernel, hull and total seed of cotton due to the foliar spraying of micro-nutrients alone or in combina-

Table 7

Average cottonseed oil content as affected by micro-elements

Micro-elements	Kernel, %	Hull, %	Total seed, %	Oil yield, kg/ha
Control	32.92	0.97	33.89	687.29
B	33.29	1.05	34.44	685.70
Zn	33.47	1.21	35.68	743.98
Mn	33.93	1.05	34.98	712.58
Mn + Zn	34.32	1.06	35.38	736.70
Mn + B	34.64	1.10	35.74	735.96
Zn + B	34.10	1.06	35.16	769.58
Mn + Zn + B	34.28	1.06	35.34	747.05

tion. These results agree with those obtained by AGAEV (1973), ANDERSON—WORTHINGTON (1973) and TAILAKOV—ATAEVA (1973).

Effect of interaction. The interaction between nitrogen fertilizer and micro-nutrients did not have any significant effect on the characteristics under study.

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PERFORMANCE OF MIXTURES OF UPRIGHT BUNCH AND SPREADING BUNCH VARIETIES OF GROUNDNUT UNDER TWO PLANT SPACINGS

KLAGES (1936) reported yields for three stem rust susceptible wheat varieties grown in individual mixtures with different percentage compositions with the stem rust resistant variety Mindum in a season when stem rust was severe. The yields of Mindum in the various mixtures were in direct relationship to the stem rust damage to the susceptible varieties. Barley variety mixtures were tested extensively by HARLAN—MARTINI (1938). In experiments with a mixture of 11 varieties of barley grown for four to twelve years at ten stations, they found evidence of early aggressiveness and increasing dominance of the local commercial type at certain stations.

SUNESON—WIEBE (1942) concluded that Vaughn barley and Ramona wheat, which were high yielding, widely adapted varieties, were poor competitors in mixtures with other varieties having slightly lower individual yields. STRINGFIELD (1959) planted 42 pairs of corn hybrids separately and as two-hybrid mixtures in three tests. He failed to show any significant yield advantage in planting the mixtures. PENDLETON—SEIF (1962) observed a yield reduction in mixing normal and dwarf corn.

The groundnut varieties M.H. 383, a spreading bunch type, and Barberton, an upright bunch, were chosen for this study. These were planted alone and in varying mixtures. Ashford, a spreading bunch type, which had been substituted by M.H. 383, was used as a check. The variety mixtures were planted at a spacing of 60 cm between ridges, 15 and 30 cm between holes and with two kernels per hole. The treatments were:

M.H. 383 alone
Barberton alone
M.H. 383, 80%: Barberton, 20%
M.H. 383, 60%: Barberton, 40%
M.H. 383, 40%: Barberton, 60%
M.H. 383, 20%: Barberton, 80%
Ashford alone

The data reported here were obtained from an experiment conducted at G.R.S.* in the three seasons 1970/71 to 1972/73. The type of soil is heavy, dark, cracking clay with a pH of about 8.5 and a low nitrogen status. The average rainfall for the three seasons was about 300 mm.

The experimental design consisted of a split-plot design with the variety mixtures as main-plots and the between-hole spacings as sub-plots. The sub-plot size was 9.9 m × 4.2 m, replicated six times. All the operations were done manually except for the land preparation. The variety mixtures were planted on 1/7 after cotton. On the day of planting the kernels were treated with Aldrex T at 2.2 g per kg of kernels. The variety mixtures were irrigated at two week intervals, reridged after 45 days (at flowering) and weeded three times at monthly intervals, starting a month after planting.

For ascertaining groundnut harvesting losses, the plants of one ridge per sub-plot were used at the time of harvesting for the following determinations:

a) percentage pods harvested (on plant)
b) percentage gleanings
c) percentage remaining in soil and thereby lost (it was necessary to dig the soil to ascertain this).

Oil content was determined by the laboratory press method (Nur 1975). The amount of pods used for shelling percentage determination was 300 g (Nur—Gasim 1975). Samples for the determination of oil and shelling percentages were obtained from the bulked seed of each sub-plot, with five determinations per sub-plot.

A seed germination test for the three varieties was conducted every season prior to conducting the experiment; it was found that the seed germination was 100%.

Ashford was introduced in 1930 and was previously the only groundnut variety grown under irrigation in Sudan. Recently, it was found that M.H. 383 (an Indian variety introduced from Nigeria) is superior to Ashford in pod yield, oil and shelling percentages. Barberton is a lower yielder than Ashford and M.H. 383, but it has a higher oil and shelling percentage than either of them.

There was a significant difference in total pod yield among the variety mixtures and the hole spacings, whereas there was no interaction between the variety mixtures and the hole spacings. Mixtures having the highest proportion of M.H. 383 yielded significantly more than those with lower proportions of M.H. 383; Barberton alone resulted in the lowest yield (Table 1). 15 cm spacing gave higher yields than 30 cm spacing for each of the variety mixtures tested. It seems that 15 cm spacing is the optimum spacing for groundnut.

The effect of variety mixtures and spacing on oil content, shelling percentage and losses at harvest is summarized in Table 1; variety mixtures were significant, whereas the

* G.R.S. = Grezira Research Station, Wad Medani, Sudan.

Table 1

Effect of spacing and variety mixtures on yield and other attributes of groundnut

Between-hole spacing (cm)	Variety mixtures						
	M.H.383 alone	Barberton alone	80% M.H.383, 20% Barberton	60% M.H.383, 40% Barberton	40% M.H.383, 60% Barberton	20% M.H.383, 80% Barberton	Ashford alone
Total pod yield (kg/ha)							
15	5398	3501	4671	4370	4086	3790	5003
30	5032	3204	4350	4100	3785	3500	4740
	Spacing S.E. ± 86.6			Variety mixtures S.E. ± 94.9			
Oil percentage							
15	49.18	52.19	49.63	50.10	50.60	50.99	48.75
30	49.21	52.08	49.64	50.00	50.50	50.87	48.70
			Variety mixtures S.E. ± 0.13				
Shelling percentage							
15	73.47	78.14	74.22	75.17	76.16	77.01	72.60
30	73.50	78.09	74.18	75.25	76.00	76.94	72.44
			Variety mixtures S.E. ± 0.25				
Losses at harvest (percentage remaining in the soil)							
15	14.8	1.5	12.4	10.0	7.6	5.1	17.7
30	15.3	1.7	12.4	10.3	7.5	5.2	18.0
			Variety mixtures S.E. ± 0.75				

spacing and the variety mixture × spacing interaction were non-significant. In the three attributes tested, Barberton was the superior one and mixtures having the highest proportion of Barberton resulted in more favourable values than those with lower proportions of Barberton.

Ashford was next to M.H. 383 in all attributes rested; each of the variety mixtures and Barberton in pure stand were superior to Ashford in oil and shelling percentages and resulted in lower harvest losses than Ashford.

Competition had an effect on the pod yield of M.H. 383 and Barberton in mixtures where M.H. 383 had the higher proportion of the mixture. There was also a dominance of Barberton in mixtures with respect to oil and shelling percentages and losses at harvest. It seems quite natural to assume that the effect of competition should be dependent upon the relative frequency of competing individuals within the population if the population is a mixture of two different genotypes.

The effect of treatments was consistent from season to season; there was no interaction of treatment × season.

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THE SUITABLE PROTEIN LEVEL FOR FEEDING DAIRY CATTLE II. PROTEIN REQUIREMENT FOR MILK PRODUCTION

Because of the shortage and high cost of plant and animal protein, a re-evaluation of the protein requirement for lactating cows is advisable. The saving of any quantity of food by giving the proper level of feed without affecting the body weight or the milk yield would indirectly participate in solving the problem of feed shortage.

An increase in the level of protein intake above the requirement has little effect on the milk yield (ARMSTRONG 1968, GORDON—FORBES 1970). Moreover, excess protein may well be harmful (MAYNARD—LOOSLI 1969). On the other hand, it has been well documented that decreasing the protein level considerably below the requirement leads to a decline in the milk yield (THOMAS 1971, DARWISH 1973).

The aim of this study is to determine the most suitable protein level for milk production. The overall effect of the protein level on milk production, N-balance and body weight change in lactating cows was ininvestigated during a fairly adequate period.

Fifteen lactating and non-pregnant Jersey cows were used to study the suitable protein level for milk production. The animals were divided into three trials as follows.

a) The first trial included six cows to study the effect of increasing the efficiency of protein utilization from 55% (control level) to 65% (i.e. decreasing the D.C.P. intake from 182% to 154% af milk protein) on the milk yield, N-retention and body weight change.

b) The second trial included five cows to determine the effect of increasing the efficiency of protein utilization from 55% to 75% (i.e. decreasing the D.C.P. intake from 182% to 133.3% of milk protein) on the milk yield, N-retention and body weight change.

c) The third trial was carried out with four cows to study the effect of increasing the efficiency of protein utilization from 55% to 80% (i.e. decreasing the D.C.P. intake from 182% to 125% of milk protein) on the milk yield, N-retention and body weight change.

Using the swing-over design (KELLNER 1926), the experimental period started on the 30th day and ended at the close of the 60th day. The period thus included 31 days. The middle day of this period is thus the 45th day, which is preceded by 15 days and followed by a further 15 days. Here one tested level was used between the initial and final control. A transition period of 29 days preceded the initial control period which lasted for 31 days. This was followed by a 29-day transition period to the tested level which continued for 31 days. The initial control level was finally reintroduced. The days in the experiments were numbered from the 1st day of the initial control period. The last day of the final control period was thus the 180th day.

The daily starch value requirements were calculated after MOLLGARD (1931) from data on the average weight, milk yield and fat percentage during the week before the experiment.

The amount of digestible protein in the ration required for producing milk protein was obtained by calculating the amount of protein in the milk produced. Assuming that 55% of D.C.P. in the ration is transfered to milk protein, as reported by REID *et al.* (1966), the amount of D.C.P. in the feed would be 1.82 times that in the milk produced. Higher protein efficiency was tested with three levels (65%, 75% and 80%), taking 55% efficiency as the control.

The N-balance was calculated during the last 10 days of each experimental period. The total faeces and urine excreted from each cow during the control and tested periods were collected using a special bag. The excreta were weighed and samples were taken for nitrogen determination.

The feeding stuffs included in the four mixtures are listed in Table 1. The feeding value and the digestible protein of the mixtures were calculated in four digestibility trials with sheep.

Statistical analyses were carried out on the data to estimate the significance of the differences between the treatments according to SNEDECOR (1967).

Milk yield. The results in Table 2 show that the differences in milk yield between the control (182%) and the tested level (154%) were not significant. These results indicate that decreasing the protein intake from 182% to 154% of milk protein had no significant effect on the milk yield. In this connection, PAQUAY *et al.* (1973) concluded that milk production could not be increased by feeding dietary protein at more than a certain critical value. They added that when the protein content of the diet was above this limiting value, the supplement of ingested-N was not utilized by the animal but was lost in the urine.

Therefore, from the economic point of view, these results encouraged the authors to test a lower level (133.3%). The results in Table 2 show that the average percentage difference from the initial control level was $2.79 \pm 4.72\%$. These differences were not statistically significant.

In general, it could be noted that reducing the protein level required for milk production from 182 to 133.3% of milk protein (i.e. by increasing the efficiency of protein utilization from 55 to 75%) had no significant effect on the milk yield. The currently recommended protein allowances for milk production summarized by REID *et al.* (1966) show that the efficiency of protein utilization for milk production ranges between 55 and 78%. These results encouraged the authors to test the 80% efficiency level.

Table 1

Feeding stuffs, feeding value and digestible protein of mixtures fed to animals in different trials

Feeding stuffs	Mixtures			
	1	2	3	4
Maize	10.0	15.0	30.0	21.0
Unified feed mixture*	80.0	65.0	60.0	49.0
Wheat straw	10.0	20.0	10.0	30.0
Starch value, %	53.72	49.97	61.33	55.17
Digestible proteint %	15.17	11.00	10.44	10.65

* Unified feed mixture contains 45% undicorticated cottonseed cake, 26% wheat bran, 7% rice bran, 17% maize, 2% molasses, 2% calcium carbonate and 1% sodium chloride.

Table 2

Effect on milk yield of feeding Jersey cows different protein levels

Cow No.	Average daily milk yield		Average daily decrease, kg	Average daily milk yield at test level		Difference	
	Initial control, kg	Final control, kg		actual, kg	calcul-ated, kg	kg	as % of initial control, %
Trial I (154%)							
1	5.2	2.0	0.027	3.8	4.2	−0.4	− 7.6
2	4.0	2.2	0.015	3.2	3.1	0.1	2.5
3	3.6	1.6	0.017	3.0	2.6	0.4	11.11
4	5.2	2.4	0.023	3.4	3.8	−0.4	− 7.69
5	4.4	2.4	0.017	3.6	3.4	0.2	4.55
6	5.6	3.0	0.022	4.4	4.3	0.1	1.78
Average	4.67	2.27	0.020	3.56	3.56	0.00	0.78 ± 2.98
Trial II (133.3%)							
7	5.72	5.55	0.0014	6.08	5.635	0.445	7.78
8	6.2	5.46	0.0062	6.19	5.83	0.36	5.81
9	6.05	5.91	0.0012	6.23	5.98	0.25	4.13
10	3.61	3.51	0.0008	3.98	3.56	0.42	11.63
11	3.02	2.31	0.0059	2.20	2.67	−0.47	−15.40
Average	4.92	4.54	0.0031	4.93	4.755	0.175	2.79 ± 4.72
Trial III (125%)							
12	5.17	2.80	0.020	3.59	3.97	−0.38	− 7.35
13	6.52	2.28	0.035	3.63	4.42	−0.79	−12.12
14	5.05	3.28	0.015	3.77	4.15	−0.38	− 7.52
15	6.65	3.66	0.025	3.83	5.15	−1.32	−19.82
Average	5.85	3.01	0.024	3.71	4.41	−0.70	−11.71 ± 2.93

The results in Table 2 show that the milk yield decreased significantly ($P < 0.05$) after feeding at 125% of milk protein (i.e. when the efficiency of protein utilization was 80%). Blaxter (1964), Armstrong (1968) and Thomas (1971) showed that a level of protein considerably below the requirement leads to a decline in the milk yield.

Moreover, the rate of decrease in the milk yield with the decreasing protein intake differed from one individual to the other. High-yielding cows (e.g. No. 15) were more affected by the low level of protein intake than low-yielding ones (e.g. No. 12). Therefore, the level of milk production should be taken into consideration when determining a suitable protein level for milk production. In this connection, PAQUAY *et al.* (1973) reported that the optimal crude-protein content in dairy rations is 15—16% when the daily milk production exceeds 20 kg, 12—13% for a production of 15—17 kg and 11—12% when the cow gives less than 10 kg milk yield.

A general analysis showed that the milk yield declined significantly ($P < 0.05$) when the efficiency of protein utilization was 80% compared with 55, 65 and 75%. On the other hand, the differences in milk yield between the 55, 65 and 75% levels were not statistically significant. Due to the shortage and high price of protein sources, the 75% level may be more economical for milk production and would be suitable for feeding Jersey cows under local conditions.

Efficiency of protein utilization. The data in Table 3 show that reducing the D.C.P. intake from 182% to 154% of milk protein did not increase the gross efficiency significantly. A return to the control level caused a highly significant ($P < 0.01$) decrease in the gross efficiency. This is due to the fact that the milk yield, and consequently the milk protein, naturally decrease as the lactation period proceeds (DARWISH 1973).

However, reducing the D.C.P. intake to 133.3% of milk protein caused a highly significant increase in the gross efficiency compared to the control level (182%). It is interesting to note that a further decrease in the protein intake to 125% of milk protein did not cause a significant increase in the gross efficiency. This is due to the decline in the protein yield after feeding this level.

When the maintenance requirement of protein was calculated according to the recommended allowance adopted by GHONEIM (1958), i.e. 50 g D.C.P./100 kg L.W., the net efficiencies were 54.9, 64.9, 75.2 and 80%. Applying the value obtained from the maintenance trials (37.5 g/100 kg L.W.), the corresponding net efficiencies of protein utilization were 50, 57,

Table 3

Effect of feeding Jersey cows different protein levels on the efficiency of protein utilization for milk

Item	Trial I			Trial II			Trial III		
	initial control	test level	final control	initial control	test level	final control	initial control	test level	finals control
D.C.P. intake g/day									
Maintenance	130.8	129.5	131.0	152	151	155	162.5	160.2	164.5
Production	325.1	232.8	325.1	347.8	254.2	347.8	429.5	189.6	429.5
Total intake	455.9	262.3	456.1	499.8	405.2	502.8	591.0	349.8	594.0
Protein out put in milk	178.6	151.2	101.2	191.1	191.1	175.5	236	151.7	132
Gross efficiency, %$^{c)}$	39.2	41.7	22.2	38.2	47.2	34.9	39.9	43.4	22.2
Net efficiency, %$^{a)}$	54.9	64.9	31.1	54.9	75.2	50.5	54.9	80.0	30.8
Net efficiency, %$^{b)}$	49.9	57.0	28.3	49.6	55.4	45.4	50.3	66.1	28.05

a) Maintenance requirement calculated as recommended by Ghoneim (1958), i.e. 50 g/100 kg L.W.

b) Maintenance requirement calculated as 37.5 g/100 kg L.W. as a results of these trials.

c) Values within a row and during the same experiment not followed by the same letter are significant at the 5% level according to Duncan's Multiple Range Test.

65.4 and 66.1%. This reveals that the net efficiency decreased significantly with increasing D.C.P. intake. These results are in agreement with the assumption that there is a curvilinear response in the milk yield to an increased input of nutrients, so that at high feeding levels there is a lower efficiency of food used for milk production.

After studying the effect of reduced D.C.P. intake on the milk yield and applying the new maintenance requirements (37.5 g/100 kg L.W.), the suitable net efficiency of protein utilization for milk production was found to be 67.35% (i.e. 148.5% of milk protein). Similarly, JUMAH *et al.* (1965) reported that the overall average net efficiency of protein utilization for lactating cows was 66.4 $\pm$ 8.2%. This efficiency would be more economic than that recommended by GHONEIM (1958), improving the efficiency from 200% to 148.5%, and thus saving 25.75% of the protein required for each kg milk produced.

N-balance. The results in Table 4 show that in spite of a reduction in the protein intake from 182% to 154% of milk protein, nitrogen was still retained in the body. These results show that the N-balance was noticeably positive during the initial control period when the N-intake was high (5.1 $\pm$ 2.6 g/day), while the lower allowance in the tested period resulted in a positive N-balance but with lower N-retention (1.6 $\pm$ 1.5 g/day). On reverting to the high N-intake in the final control, the retention of N remained at a slightly higher level, being about 12% higher than that observed when using the same level in the initial control period. This increase in N-retention during the final control may be due to the fact that the total yield of milk protein was naturally lower than that of the initial control period. These results indicated that the 154% level also provided the cows with more protein than necessary.

Transfering to the 133.3% level of milk protein also resulted in a positive N-balance. These results indicate that the 133.3% level may also be slightly higher than that required for milk production.

Therefore, it could be concluded from the above results that a surplus protein intake allowed an excess amount to be stored in the body. This can be beneficial and indicates that during lactation the animals have the ability to retain large amounts of protein, which could be used if conditions changed in such a way that the protein intake would not provide the necessary protein for milk production.

The results of Trial III given in Table 4 show that there was a depletion of protein in the body tissues of the cows when they were fed the 125% level of milk protein. It can thus be stated that this protein level (80% efficiency) was below the minimum requirement. A lower protein intake than required would definitely be harmful, as it results in atrophy of the muscular system, the occurrence of hormonal disturbances during the heat period and pregnancy, and a reduction in milk yield, as indicated by HARRANEN (1965).

On reverting to the final control ration (182% of milk protein) after the depletion period, the high protein level in the feed was associated with a noticeably higher positive N-balance which was about 1.4 times that during the initial control period. This was certainly due to the fact that the animal tried to recover and retain more protein when a high intake permitted this. Similar results were recorded by DARWISH (1973).

It was clear that N-balance studies with dairy animals could be a good guide for testing the overall effect on the N-level in the diet and determining the suitability of the level. Combining the two methods (N-balance and protein efficiency) would give more reliable results.

Body weight change. The data in Table 5 show that in Trial I the differences between initial body weight and test weight, and initial weight and final weight were -2.5 and 0.6 kg respectively. Statistical analysis showed that the percentage differences were insignificant for the test and final periods.

The results of Trial II (Table 5) showed that the animals lost weight when they were fed on the tested ration, but the animals gained weight during the final period. The average weight gain was 4.8 $\pm$ 3.9 kg, being 1.68 $\pm$ 1.3% of the initial weight. These results indicated

Table 4

Effect of feeding Jersey cows different protein levels on the N-balance (maintenance protein requirement being 50 g D.C.P./100 kg L.W.)

	Trial I			Trial II			Trial III		
	initial control 182%	test level 154%	final control	initial control	test level 133.3%	final control	initial control	test level 125%	final control
N intake:									
Maintenance, g	44.2	44.6	43.7	51.6	51.6	51.0	54.8	55.6	53.8
	±11.1	12.2	10.4	7.9	7.6	7.6	7.5	8.5	8.8
Production, g	82.7	56.2	82.7	86.8	52.6	86.8	103.8	41	103.8
	±13.8	8.4	13.8	26.4	16.6	26.7	15.4	2.2	15.4
Total N intake, g	126.9	100.8	126.4	138.4	104.2	137.8	158.6	96.6	157.6
	±24.0	18.0	23.6	27.9	19.3	28.6	13.2	10.3	11.8
Total digestible N intake	77.9	57.8	77.7	84.2	63.7	83.9	97.4	56.6	97.0
	±10.6	12.4	11.1	14.3	12.6	14.0	8.9	8.3	10.6
N output:									
Milk, g	28.7	23.3	15.7	29.6	29.0	28	36.3	23.8	20.5
	±5.1	3.3	3.4	8.1	9.0	9.0	5	1	2.9
Faeces and urine, g	93.1	75.8	105.0	105.5	73.3	106.1	114.7	79.7	126
	±18.6	15.8	19.7	19.5	13.7	20.3	13.6	13.2	7.7
Total output, g	121.8	99.1	120.7	135.1	102.3	133.9	151.	103.5	146.5
	±23.2	18.9	22.3	27.2	13.7	28.5	17.0	13.4	7.8
N balance, g/day	5.1 ± 2.6	1.7 ± 1.2	5.7 ± 2.9	3.3 ± 1.2	1.9 ± 2.5	3.9 ± 0.7	7.6 ± 3.9	6.9 ± 3.9	11.1 ± 4.3
% of N intake	4.0 ± 2.1	1.6 ± 1.5	4.5 ± 2.1	2.4 ± 0.9	1.8 ± 3.0	2.8 ± 0.8	4.7 ± 3.0	7.1 ± 3.2	7.04 ± 2.4

Table 5

Effect of feeding Jersey cows different protein levels on body weight change

Trial	Initial control	Test level			Final control		
	average weight on the middle day, kg	average weight on the middle day, kg	difference from initial weight, kg	difference from initial weight, %	average weight on the middle day, kg	difference from initial weight, kg	difference from initial weight, %
I. (154%)	261.50	259.00	−2.50	−0.90	262.10	0.60	0.53
±	63.60	62.40	1.7	0.8	60.20	2.30	1.71
II. (133.3%)	304.20	302.20	−2.00	−0.60	309.00	4.80	1.68
±	46.50	44.80	1.10	1.00	45.10	3.90	1.30
III. (125%)	325.00	320.25	−4.75	−1.50	329.00	4.00	1.20
±	46.70	48.70	3.60	1.20	53.50	4.80	1.50

that surplus protein might allow an excess amount to be stored in the body. However, the loss in weight during the test period and the gain during the final period were not significant.

Reducing the D.C.P. intake to 125% of milk protein (Trial III) caused a greater loss in body weight, while a return to the control level caused a substantial increase in weight. It could be noticed that the increase in body weight was higher during the final period after a greater decrease in the test period. This was certainly due to the fact that the animal tried to recover and to gain weight, or to retain more protein (Darwish 1973). But the loss in weight during the test period and the gain during the final period were not significant.

These data showed that reducing the D.C.P. intake from 182% to 125% of milk protein had no significant effect on body weight change. These results are in agreement with those reported by Coppock *et al.* (1968), who reported that the ability of cows to mobilize tissue protein for the synthesis of milk is small relative to their ability to mobilize energy.

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INHERITANCE OF FLESH COLOUR, SEED COAT CRACKS AND TOTAL SOLUBLE SOLIDS IN WATERMELON AND THEIR GENETIC REXATIONS

I. QUALITATIVE CHARACTERS

It is interesting to know the genetic behaviour of economic characters in watermelon. such as flesh colour, cracks on the seed-coat and so on. This study was carried out to determine the mode of inheritance of these characters.

The genetic behaviour of watermelon with regard to flesh colour was reported by PORTER—BUNNETT (1936), POOLE (1944), SHIMOTSUMA (1960, 1963), IVANOFF (1962) and ABD EL-HAFEZ (1969).

The three cultivars of watermelon, Congo, Kaho and Leeby, which were used in this investigation, showed great differences in one or more of their distinctive characteristics, as described by ALLAM (1976).

The cultivars were selfed for more than ten successive generations before crossing in the Vegetable Experimental Station of the Faculty of Agriculture, Cairo University at Giza. The parents, F_1, F_2 and Bc generations obtained from 1972 to 1974 were planted on March 23rd 1975.

Six crosses (straight and reciprocals) were made for this study as follows: 1. Kaho× ×Leeby 2. Leeby×Kaho 3. Congo×Leeby 4. Leeby×Congo 5. Kaho×Congo 6. Congo× Kaho.

The characters examined were flesh colour and cracks on the seed coat, which were judged visually.

The chi-square test was applied for the analysis of the data obtained from these characters.

1. Flesh colour. This character was studied in the following six crosses:

1. Kaho×Leeby   2. Leeby×Kaho.

The results of the staight and reciprocal crosses are presented in Table 1. The Kaho and Leeby cultivars had orange and whitish-yellow flesh colour, respectively. All the F_1 plants had orange flesh, indicating the dominance of orange over whitish-yellow.

Two F_2 populations were studied, each of which segregated in a ratio that was a good fit to 3 orange : 1 whitish-yellow. Thus, the Kaho and Leeby parents apparently differed in one pair of genes.

On backcrossing F_1 plants to the recessive parent, i.e. Leeby, the progeny produced segregated in a ratio of 1 orange : 1 whitish-yellow. On the other hand, the backcross to the

Table 1

Flesh colour and cracks on seed coat in F_1, F_2 and first backcross populations in the crosses studied

Characters and crosses	F_1	F_2 segregation			Ratio	$\varkappa^2$	P
1. Flesh colour		*Orange*	*Whitish-yellow*				
a) Orange × Whitish-yellow							
Kaho × Leeby	Orange	56	22		3 : 1	0.4273	0.50–0.70
BC.P_2		7	5		1 : 1	0.1667	0.50–0.70
b) Whitish-yellow × Orange							
Leeby × Kaho	Orange	64	24		3 : 1	0.2443	0.50–0.70
BC.P_2		21	0		—	—	—
		Whitish-yellow	*Red*				
c) Red × Whitish-yellow							
Congo × Leeby	Whitish-yellow	49	21		3 : 1	0.9333	0.30–0.50
BC.P_2		30	—		—	—	—
d) Whitish-yellow × Red							
Leeby × Congo	Whitish-yellow	57	19		3 : 1	0.000	> 0.99
BC.P_2		16	16		1 : 1	0.0000	> 0.99
		Orange	*Whitish-yellow*	*Red*			
e) Orange × Red							
Kaho × Congo	Orange	39	13	20	9 : 3 : 4	0.2963	0.80–0.90
BC.P_2		5	3	8	1 : 1 : 2	0.5000	0.70–0.80
f) Red × Orange							
Congo × Kaho	Orange	37	11	18	9 : 3 : 4	0.2869	0.80–0.90
BC.P_2		18	0	0	—	—	—
2. Seed-coat cracking		*Non-cracked*	*Cracked*				
a) Non-cracked × Cracked							
Kaho × Leeby	Non-cracked	55	23		3 : 1	0.8376	0.30–0.50
BC.P_2		9	12		1 : 1	0.4286	0.50–0.70
Congo × Leeby	Non-cracked	47	22		3 : 1	1.7440	0.10–0.20
BC.P_2		14	16		1 : 1	0.1334	0.70–0.80
b) Cracked × Non-cracked							
Leeby × Kaho	Non-cracked	61	27		3 : 1	1.5151	0.20–0.30
BC.P_2		21	0		—	—	—
Leeby × Congo	Non-cracked	53	23		3 : 1	1.1228	0.20–0.30
BC.P_2		30	0		—	—	—

dominant parent, i.e. Kaho, produced plants exhibiting orange flesh colour. Evidence for one pair of genes governing the colour of the flesh was thus obtained.

3. Congo × Leeby 4. Leeby × Congo.

The data are presented in Table 1. Congo had fruits with red flesh, while Leeby produced fruits of whitish-yellow flesh colour. The F_1 plants produced fruits with whitish-yellow flesh. Thus, the dominance of whitish-yellow over red flesh colour was evident.

Each F_2 population segregated on the basis of 3 whitish-yellow : 1 red. Evidently, the two parents can be differentiared by one pair of genes governing the flesh colour.

The backcross to the parent carrying the dominant character produced progeny with whitish-yellow flesh colour. However, on backcrossing F_1 plants to the recessive parent, i.e. Congo, the progeny segregated in a ratio of 1 whitish-yellow : 1 red.

The results of this cross indicate that the two parents used to study the mode of inheritance of whitish-yellow and red flesh colour differed in one pair of genes.

5. Kaho × Congo 6. Congo × Kaho.

As shown in Table 1, Kaho had fruits with orange flesh whereas Congo had fruits with red flesh. The F_1 plants had druits with orange flesh. This would indicate the dominance of orange flesh colour over red flesh.

Each F_2 population proved to be homogeneous with a segregation ratio of 9 orange : 3 whitish-yellow : 4 red flesh. Thus, two pairs of genes differentiated the two parents. One parent possessed the two pairs of complementary genes in a homozygous dominant, and the other parent in a recessive condition. The epistasis of the recessive gene was evident.

The backcross to P_2, i.e. Congo, gave a progeny having a segregation ratio of 1 orange : 1 whitish-yellow : 2 red, while plants of the backcross to Kaho have progeny of orange flesh colour, like that of the dominant parent. These backcross data indicate that the orange flesh colour of F_1 plants differed from the red flesh of the Congo parent by two pairs of genes.

The following factorial analyses are suggested for the flesh colour studied in the six crosses discussed above:

First: For crosses 1 and 2 having the Kaho and Leeby cultivars as parents:

P_1	WWRR	Orange	Kaho
P_2	WWrr	Witish-yellow	Leeby
F_1	WWRr	Orange	
F_2	WWRR 1 WWR 2	3 Orange	
	WWrr	1 Whitish-yellow	
$BC.P_1$	WWRR, WWRr	Orange	
$BC.P_2$	WWRr	1 Orange	
	WWrr	1 Whitish-yellow	

Second: For crosses 3 and 4, the parents of which were the Congo and Leeby cultivars:

P_1	wwrr	Red	Congo
P_2	WWrr	Whitish-yellow	Leeby
F_1	Wwrr	Whitish-yellow	
F_2	WWrr 1 Wwrr 2	3 Whitish-yellow	
	wwrr	1 Red	
$BC.P_1$	Wwrr	1 Whitish-yellow	
	wwrr	1 Red	
$BC.P_2$	WWrr, Wwrr	Whitish-yellow	

Third: In crosses 5 and 6 between the Kaho and Congo cultivars, the fruits of the F_1 plants had orange flesh colour. A ratio of 9 orange : 3 whitish-yellow : 4 red was obtained in the F_2.

P_1	WWRR		Orange	Kaho
P_2	wwrr		Red	Congo
F_1	WwRr		Orange	
F_2	WWRR	1	9 Orange	
	WwRR	2		
	WWRr	2		
	WwRr	4		
	WWrr	1	3 Whitish-yellow	
	Wwrr	2		
	wwRR	1	4 Red	
	wwRr	2		
	wwrr	1		
$BC.P_1$	WWRR	1	*Orange*	
	WwRR	1		
	WWRr	1		
	WwRr	1		
$BC.P_2$	WwRr		1 Orange	
	Wwrr		1 Whitish-yellow	
	wwRr	1	2 Red	
	wwrr	1		

It is clear from the suggested analyses that the presence of W and R genes together gave rise to orange colour. The presence of W and r gave rise to whitish-yellow colour and the presence of w and r or w and R gave rise to red colour. Thus, r is epistatic over w, revealing a case of recessive epistasis.

A concluding remark would be that all the colours studied in this investigation for fruit flesh were expressed by the action of the following gene pair:

A dominant gene "W" for the expression of whitish-yellow.

A dominant gene "R" or a recessive gene "r" for red colour.

The orange colour is expressed by the interaction between "W" and "R".

The mode of inheritance of flesh colour was not reported in the available literature as resembling the present data. But Porter—Bunnett (1936) stated that red flesh colour was dominant over yellow and determined by a single dominant gene. Poole (1944) indicated that canary-yellow was dominant over pink whereas golden yellow flesh was recessive to red. Shimotsuma (1960) found that white flesh colour was dominant over red flesh; but Ivanoff (1962) indicated that red flesh colour was incompletely dominant over yellow. Shimotsuma (1963) showed that white flesh colour was dominant over red flesh and controlled by two genes, WY being white, wY yellow and wy red. Studies made by Abd El-Hafez (1969) on flesh colour in crosses between diploid and tetraploid cultivars revealed that the triploid plants produced fruits with orange flesh or orange splashed with red when the cross was made between a tetraploid having red flesh and a diploid with orange flesh. Evidently the orange flesh predominated.

II. Cracks on Seed-Coat

Four crosses were used to study the mode of inheritance of this character. These crosses were:

1. Kaho × Leeby	3. Congo × Leeby
2. Leeby × Kaho	4. Leeby × Congo.

As shown in Table 1, the non-cracked and cracked seed coats were manifested by crossing Kaho or Congo to Leeby. The F_1 plants produced seeds with non-cracked seed coats. The dominance of non-cracked seed coats over cracked ones was indicated.

A homozygous segregation of the four F_2 populations studied was demonstrated on the basis of 3 non-cracked : 1 cracked, indicating that the non-cracked/cracked phenotype was depending for its expression upon a single pair of genes.

On backcrossing F_1 plants to the recessive parent, i.e. Leeby, the progeny segregated to fit a 1 non-cracked : 1 cracked ratio, whereas the backcross to the parent carrying the dominant character produced progeny with non-cracked seed coats and this confirmed the evidence for monogenic inheritance of this character.

This pair of genes is tentatively designated Cr-cr, with non-cracked dominant over cracked. There is no previous record in the available literature on the inheritance of cracking of seed coats in watermelon.

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PÁL, GY.: **In recent years the annual average precipitation in Hungary has ranged between 430 and 720 mm, of which 115—280 mm falls between March and August. Do you think that Hungary belongs to the zone where irrigation is conditional, i.e. where varying quantities of irrigation water need to be supplied to obtain large yields, or should irrigation become an integral part of the agrotechnics?**

ALMÁSI, T.: On the basis of its geographical situation and climatic conditions Hungary belongs, in my opinion, to the zone where irrigation is conditional on precipitation. Statistical data collected over many years prove that whether the annual precipitation is analysed or the amount of precipitation from April to September during the vegetation period, there is a 15–20% probability that dry, droughty weather will occur and approximately the same likelyhood that the growth season will be so rainy that irrigation is not needed at all. To look at the question from a different point of view, Hungary is an area of conditional irrigation if the role of water is considered as a limiting factor in the dynamic technical development of agriculture, even in years with an average amount of precipitation. Although, factors other than water can theoretically be adjusted to the minimum factor, this is no solution in the long run, and irrigation becomes necessary sooner or later, even in periods of average precipitation.

ANTAL, E.: As regards plants with lower water requirements Hungary falls within the zone where irrigation is conditional on precipitation, but in the case of certain crops (meadow,

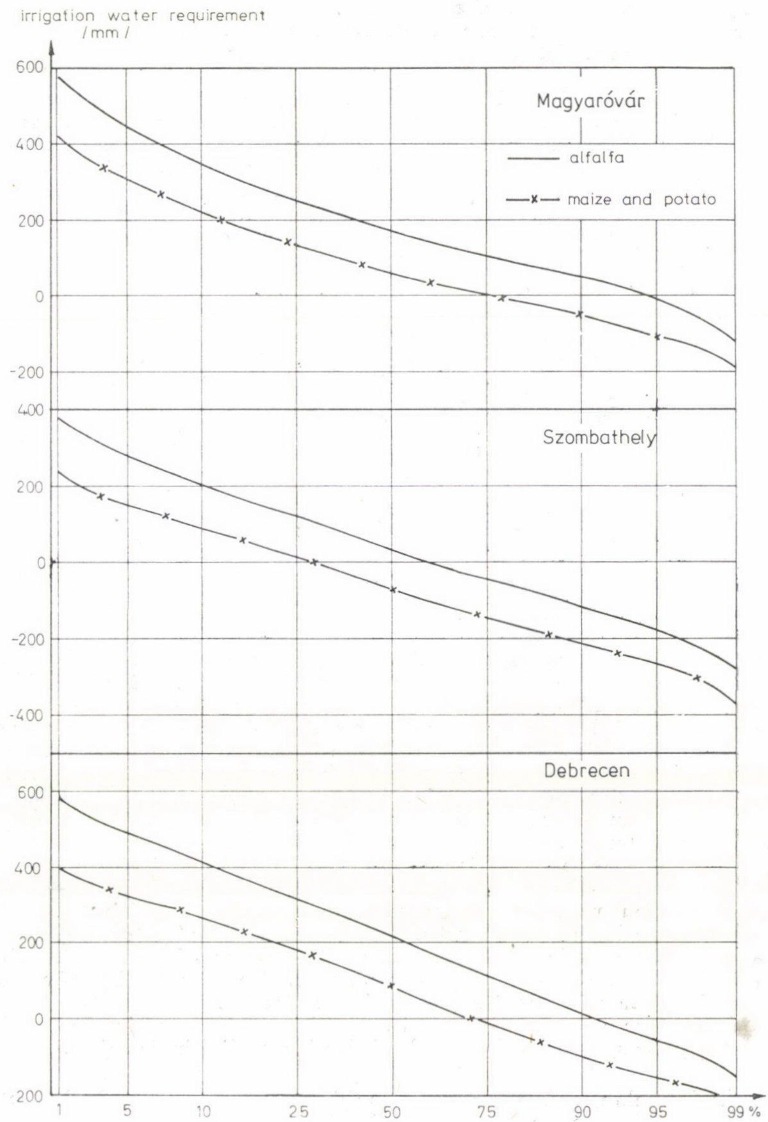


Fig. 1. **Empirical distribution function of irrigation water requirement on the basis of climatic data between 1901 and 1975**

pasture, alfalfa, rice and most vegetables) irrigation should become an integral part of the agrotechnics. According to the results of agrometeorological surveys in a large part of Transdanubia, in the northern regions of the country and in North-East Hungary, the water requirements of the crops are satisfied in most cases, though a considerable proportion of the water must be supplemented. In the Great Plain it seldom happens that irrigation is not needed in a whole crop year (e.g. 1965–66). Consequently, the water deficiency (the need for irrigation water) varies with the region, the variety and the crop year, and the modern irrigation systems should consider the actual water deficiency and irrigation water requirement of the given vegetation period, rather than

irrigation norms. Changes in the irrigation water requirements for maize, potato and alfalfa in three climatic regions of Hungary are clearly shown by the empirical distribution function in Fig. 1.

ÁCS, A.: No answer uniformly valid for the total area of the country can be given to this question. Hungary, though not a large country, has a climate which varies year by year, and from one region to the other. The average distribution of precipitation over many years shows that the region east of the River Tisza, and particularly Great Cumania, are more arid than Transdanubia, for example, or the northern hills.

Consequently, these latter areas belong to the zone where irrigation is conditional on precipitation, while on the drier, warmer, more extreme central areas of the region east of the Tisza, irrigation should form an integral part of the agrotechnics.

BALLA, L.: The annual amount of precipitation in Hungary is sufficient for the native and acclimatized crops. The problem lies in the distribution of the precipitation, though even this is not bad in the extreme. The climate of Hungary, though not optimum, is quite suitable for agricultural production, as proved by the yield averages obtained in recent years for the major crops.

Since the distribution of precipitation is not ideal, there are months almost yield averages could be further increased. Therefore, in my opinion, Hungary should be considered as an area where irrigation is conditional on precipitation. The country should make arrangements for supplementary irrigation to be applied whenever needed on at least 15% of the agricultural area. The horticultural plants, which demand continuous irrigation, belong to a different category.

BORKA, GY.: The process of transpiration in plants is controlled for the most part physiologically. In spite of this, on quite a large area of Hungary the transpiration of plants is determined mainly by climatic factors. High air temperature, and the low relative humidity frequently associated with it, together with the wind, induce such intensive transpiration that even if the soil contains sufficient water, which is readily available to the plants, at times the water uptake cannot keep pace with the increased water discharge. (The furling up of maize leaves is a well-known phenomenon on the Great Plain.) The disruption of the water balance is caused, among others things, by the anatomy of the plant. The water molecules have to overcome much greater obstacles to reach the water transport pathway (lipophilous membranes, plasma, endoderm, inner space) than is involved in the diffusion to vapour of water condensed on the surface of the stomata.

This is why transpiration in the mesophyll type of plants (which includes cultivated plants) shows a two-peaked curve on warm sunny days. The closing of the stomata at about noon is a change made necessary by the deficient water saturation of the cells (including stomal cells) rather than a "wise" defence against excessive transpiration. The closing of the stomata not only prevents CO_2 intake but also involves overheating due to the absence of transpiration. The daily rhythm of carbon dioxide assimilation is therefore similar to that of transpiration.

Thus, the unfavourable ecological conditions mentioned in the question can be successfully changed by "refreshing" apirrigation applied in due time.

BUDAVÁRI, K.: I should not put the question in this way, as there is no doubt that Hungary does indeed belong to the zone of conditional irrigation.

Therefore,

— to obtain large yields a yearly varying amount of irrigation water must be supplied, but a certain quantity of water is needed every year (except for winter wheat);
— it is only practicable to introduce irrigation on part (about 20—25% over the next 25—30 years) of the agricultural area of Hungary.

When irrigation is introduced it must become an integral part of the agrotechnics, otherwise the costs of investment, maintenance and operation will not be refunded.

CSELŐTEI, L.: Irrigation, as a plant tending operation, is part of the agrotechnics. When planning the production technology, including irrigation, the requirements of the plant should be taken into consideration and satisfied (under the given natural, technical and economic conditions) as required by production aims, keeping economic efficiency in view. The production aims and consequently the importance of production technology factors and their ratio to one another are continually changing owing to developments in the biological knowledge, technical conditions and social circumstances which make it possible to fulfil the requirements of the plants. Therefore, irrigation and the factors which depend on it or can be influenced by it have to be considered and applied in the light of the current aims and conditions of production. In elaborating the pattern of irrigation — determining the method and time of irrigation and the amount of irrigation water — the trend and the extent of the factors most important under the given conditions must be clarified [CSELŐTEI, L. (1965): Az öntözés rendszerének tényezői a zöldségnövényeknél (Factors in irrigation systems for vegetable crops). Academy doctor's thesis. Manuscript. 332; CSELŐTEI, L. (1971): Az öntözés fejlesztésének alapjai a zöldségtermesztésben (Bases of irrigation development in vegetable growing). (Academic inaugural lecture.) Agrártud. Közl., **30**, 53—66].

In this respect horticulture, with its wide range of crops and involved production processes, should be considered differently than field crops or meadows and pastures.

First of all, it is necessary to clarify what we understand by the term: zone where irrigation is conditional. If it means that some crops can be successfully and efficiently grown there without irrigation in most years, the question can be answered in the affirmative. With other crops, however, irrigation must be an integral part of the agrotechnics in such zones in Hungary. I am thinking here not only of rice, which is an aquatic plant, but also of several vegetable crops, e.g. paprika, cabbages, etc. Previously, these crops were grown mostly on low-lying areas with high ground-water tables without irrigation; since cabbages have a long vegetation period they are still grown on such areas in some cases even today. From the point of view of the water supply, in such places even without irrigation the plants are exposed to conditions similar to those in an irrigation farming system. These soils are cold, however, and remain moist until late spring. Thus cultivation cannot be started until quite late, so these areas are not suitable for early crops. Apart from this their use in large-scale production is limited because they consist of small areas of irregular shape. So today the plants mentioned are grown on other types of soil, where the high ground-water table has no role in the water supply, and are always irrigated [CSELŐTEI, L. (1962): Kertészeti növények öntözése (Irrigation in horticulture). Agrártud. Közl., **20**, 197—205].

There are other reasons for which irrigation may become an integral part of the agrotechnics. In the case of once-over mechanical harvesting in vegetable production, for example, simultaneous emergence, uniform rapid development, fruit setting and ripening, etc. are indispensable conditions. These are all made up of many factors, but the greatest effect can be attained by irrigation, which promotes germination, growth, fruit setting, ensures the effect of nutrients and herbicides, etc. [CSELŐTEI, L. (1974a): A zöldségtermelés és az öntözés fejlesztésének összefüggései (Relationships between vegetable production and irrigation development). Kertgazdaság, **6/2**, 43—54; CSELŐTEI, L. (1974b): What are the problems in the development of field experiments? Acta Agron. Hung., **23**, 495—500; CSELŐTEI, L. (1978a): Az esőszerű öntözés minőségéről a zöldségtermesztésben (Quality of sprinkler irrigation in vegetable production). Kertgazdaság, **10/4**, 15—24].

As the intensity of production increases, the additional investment required for irrigation is becoming more and more economical in many crops, and beyond a certain limit becomes an indispensable element of the agrotechnics. For example, a 20—25 t/ha yield of tomato can usually be obtained in Hungary without irrigation. If the production target is 30—35 t/ha irrigation is already desirable, while for an even higher yield it becomes indispensable, especially with the method of direct sowing, when it increases the reliability of yield and promotes the simultaneous ripening of the fruit.

The number of occasions when irrigation is applied and the amount of irrigation water may vary greatly from year to year; moreover, there may be years when a complementary water supply becomes unnecessary even in farms where irrigation forms an integral part of the agrotechnics. Under the extreme weather conditions of Hungary this is natural, as shown by a long-range tomato irrigation experiment carried out between 1964 and 1976 on sandy soil. The crop results obtained in this experiment for treatments given no irrigation, irrigated once in the critical period (in the first phase of the plant's main water consumption period, usually at the end of June and the beginning of July) and given a regular water supply consisting of 40 mm at a time at 60% soil water capacity are presented here, together with the number of occasions when irrigation was applied to the latter treatment. For the irrigated treatments the yield surplus obtained per 40 mm irrigation water (i.e. per irrigation) was also calculated (Table 1).

The table clearly shows that in some years irrigation had hardly any or no effect; in fact, in rainy, cold years a yield-depressing effect was sometimes observed. This latter was even more obvious when regular irrigation was carried out on the basis of

Table 1

Tomato yields (healthy fruit) obtained with different levels of water supply
Variety: K.42.
Gödöllő, 1964–1976

Year	Non-irrigated	Irrigated once in the critical period 40 mm	Surplus yield due irrigation	Regularly irrigated at 60% water capacity	Surplus yield per irrigation	Number of irrigations	Precipitation, mm	Mean temperature, °C
	q/ha						in the growth season (15th May to 30th August)	
1964	543.1	682.4	139.3	697.2	51.4	3	276.4	19.9
1965	318.9	329.0	10.1	250.0	—	4	310.3	18.2
1966	759.2	710.0	—	678.4	—	4	324.9	18.9
1967	276.8	309.4	32.6	563.3	47.8	6	193.2	20.8
1968	256.5	393.6	137.1	589.6	66.6	5	158.4	20.3
1969	315.1	477.8	162.7	676.9	72.4	5	213.1	19.9
1970	432.3	596.0	163.7	588.1	77.9	2	278.2	19.5
1971	410.2	577.4	167.2	528.6	23.7	5	187.7	21.0
1972	169.1	137.0	—	126.8	—	2	376.8	19.9
1973	380.2	480.0	99.8	651.6	54.3	5	177.8	20.1
1974	253.6	418.4	164.8	573.1	79.9	4	166.7	19.5
1975	581.7	441.4	—	359.0	—	3	342.3	20.1
1976	270.8	284.5	13.7	682.7	82.4	5	126.0	19.8
Average	382.1	449.0	66.9	535.8	38.4	4	240.9	19.8

the soil water content. This suggests that in rainy, cold years a lower soil water content is sufficient to satisfy the water requirements of the plant. Under such conditions other factors in the complex effect of irrigation (lower soil and air temperature, higher humidity, temporary lack of ventilation in the soil, etc.) cause an unfavourable effect.

In crops which are more sensitive to heat than tomato is (e.g. cucumber) irrigation in cool, rainy years is even less effective, while in dry, warm years it yields greater results [Cselőtei, L. (1971): Az öntözés fejlesztésének alapjai a zöldségtermesztésben (Bases of irrigation development in vegetable production). (Academic inaugural lecture.) Agrártud. Közl., **30**, 53—66; Cselőtei, L. (1974a): A zöldségtermelés és az öntözés fejlesztésének összefüggései (Relationships between vegetable production and irrigation development). Kertgazdaság, **6/2**, 43—54; Cselőtei, L. (1974b): What are the problems in the development of field experiments? Acta Agron. Hung., **23**, 495—500; Varga, Gy. (1972): A hőmérséklet, a víz és a termés összefüggései az uborkánál (Relation between temperature, water and yield in cucumber). Agrártud. Közl., **31**, 319—331; Varga, Gy. (1974): Az uborka öntözésének kapcsolata a termesztett fajtával és az időjárással (How cucumber irrigation is related to the variety and the weather). ATE Mg. Karának Közleményei, 193—200].

DEBRECZENI, B.: Hungary as a whole belongs to the zone where irrigation is conditional on rainfall, but on the areas of the Great Plain where irrigation systems have been set up irrigation must become an integral part of the agrotechnics if large reliable yields are to be obtained.

FRENYÓ, V.: To begin with, I think that under Hungarian conditions the wider introduction of irrigation is important from the point of view of plant physiology. Regions where lasting droughts do not often occur hardly exist in Hungary, particularly in July and August, when there is not even any dew at night. Care must be taken, on the other hand, not to apply irrigation after the same pattern everywhere. The method and rate of irrigation should vary with both the region and the crop. Rice is perhaps the only exception, since in Hungary the dry cultivation of rice is still at the experimental stage and rice is grown everywhere using flooding.

Irrigation demands thorough professional knowledge and close co-operation with agrometeorologists. It must be known, for example, whether any rain during the period in question will be lasting or of a temporary nature, because an unexpected rainy period can do greater damage than a temporary shortage of water. Water supplied in excess may not only cause disturbances in the respiration of the roots but also cool down the soil, thus making nutrient uptake difficult. Irrigation should thus be adjusted to the metabolism of the plant, and the basic principle should be to give less water than needed rather than more, because superfluous amounts of water can only be removed from the soil quickly enough in a few places.

The weather and the distribution of precipitation during the growth season are rather varied in Hungary, especially on the Great Plain. The annual precipitation average in the middle reaches of the River Tisza is often below 500 mm. Although, the situation is much better in the western parts of the country, nevertheless, in the environs of Sopron the average precipitation is seldom above 710 mm, and does not exceed 850 mm even on the south-western border, the rainiest region of Hungary.

The distribution of precipitation in Hungary can be well characterized taking Budapest as an example. Here the annual amount of precipitation is about the same as in London (611 litres/m^2 including water from thawing snow), yet the difference between the parks of the two cities is enormous. In London the distribution of precipitation over the year is relatively even; it rains almost every day but the rainfall is rarely heavy. In Hungary, on the other hand, heavy rainfalls alternate with completely dry periods almost everywhere, except in the western part of the country.

In theory, even an average precipitation of less than 500 mm would not, in fact, put a limit to dry farming. According to the average value of the transpiration coefficient 1 kg/m^2 dry matter can be produced using 0.5 m^3 water, which is equivalent to 500 mm of precipitation. However, the agriculture of Hungary produces only about half of the theoretical value: 0.5 kg/m^2 plant dry matter, that is, only half of the available limited amount of precipitation is directly utilized. The other half never reaches the plant organism; it is lost mostly through physical evaporation and leakage.

Part of Hungary belongs to the climatic zone where the annual average amount of precipitation is about 500 mm. In such relatively dry and hot regions, particularly along the middle course of the River Tisza, irrigation should be an organic part of the agrotechnics if yields larger and more reliable than the present ones are to be attained. But I think that even in the less dry, western part of the country arrangements should be made for conditional irrigation, due to the fluctuation of the weather. The assessment of the financial, economic, investment, work organization and legal implications naturally falls outside my sphere.

FÜRI, J.: Owing to the extremely varying amount and uneven distribution of precipitation during the whole year in general, and in the growth season in particular, Hungary belongs to a zone of occasional rather than regular irrigation. The primary task of irrigation is to ensure a uniform water supply (supplement of precipitation) for the plant. In the case of grapes the greatest role of irrigation is in bud differentiation- However, the amount of irrigation water to be used is not the same each year but varies according to need.

GYENGE, J.: The area of Hungary, particularly that part of it which is suitable for arable cultivation, is not very large, but in spite of this, due to the unusual natural conditions (with respect to soil, climate, situation, possibility of irrigation, etc.) distinct regional units have developed or could be developed in the country.

These regional units should not be understood to mean administrative areas, but rather areas with special, homogeneous conditions. Only after a careful examination of the areas developed or in the process of developing in this way can unequivocal decisions be made concerning the necessity of irrigation. The annual amount of precipitation is, is, in my opinion, only one of the important viewpoints to be considered in making a correct decision.

There are regions even within the small area of Hungary where irrigation should become an integral part of the agrotechnics, e.g. the Békés-Csanád loess table, the Debrecen loess table, etc.

In other districts, e.g. Nagysárrét, if relatively large yields are to be obtained the natural precipitation must be supplemented by irrigation at a rate varying from year to year (in Nagysárrét it is chiefly because of the soil conditions that conditional irrigation must be applied).

In the southern part of Baranya county, for example, with its unusual precipitation conditions, the question of irrigation may not even arise — and if so, only incidentally.

The above distinction, made on the basis of the natural conditions, is necessary primarily because irrigation as an agrotechnical procedure cannot be isolated from the environment it is applied in, and is only one of the essential elements for attaining large yields. There is not much significance in the fact that a region requires a certain amount of irrigation water if the application of this water involves enormous dangers because of the water regime and physical and biological properties of the soil.

Harmati, I.: At the present high level of production it is, in my opinion, a debatable point whether Hungary belongs to the zone where irrigation is conditional on precipitation, since the water requirement of an overwhelming proportion of cultivated plants is not satisfied by natural precipitation. The potential productivity of sugar-beet, potato, maize, alfalfa, grasslands and most horticultural crops is not sufficiently exploited due to lack of water. This can only be achieved under irrigated conditions. A steady high yield level without any significant fluctuation can only be ensured with irrigation. This is of particular importance for soils with a poorer water regime, where the yield level is both unsatisfactory and fluctuating. Even plants with lower water requirements (e.g. wheat) need supplements of water quite frequently.

For most crops in Hungary irrigation must become an integral part of the agrotechnics. The amount of irrigation water to be supplied to the different plant species and varieties on each occasion and over the whole season depends on the precipitation and soil conditions, however, which means that a different amount of irrigation water has to be distributed each year. This is also necessitated by economic considerations.

Horváth, I.: As the question itself suggests, the amount of precipitation in the vegetation period is generally small in Hungary. It is however, the distribution in space and time rather than the amount of precipitation that causes the main problem; moreover, the amount and distribution in time of precipitation on a given area may vary greatly from year to year. Therefore, in some regions of the country irrigation is needed every year as a constant element of the agrotechnics. Other parts of the country, on the other hand, belong to the zone where irrigation is conditional on precipitation.

Walter's climate diagrams (Fig. 1) show the humidity conditions in four agriculturally important regions, as well as in one of the driest and (excluding the mountains) one of the rainiest areas of Hungary. It can be seen that on the driest areas, e.g. in the neighbourhood of Monor, the climate is almost arid, especially in July and August. It follows that on such areas irrigation is absolutely necessary, particularly for row crops. Besides the existing reservoirs and irrigation systems the planned Danube-Tisza canal, which will ensure the possibility of irrigation in one of the driest regions of the country, is of great importance in this respect.

According to the climate diagrams, however, particularly in the whole of the southern part, but also in the northern part of the Great Plain irrigation is generally needed. (The figures on the climate diagrams indicate the order of importance of irrigation.)

The hilly country of Transdanubia does not generally need to be irrigated owing to the relatively uniform distribution and sufficient quantity of precipitation; the north-west part of Transdanubia, on the other hand, belongs to the zone where irrigation is conditional on precipitation.

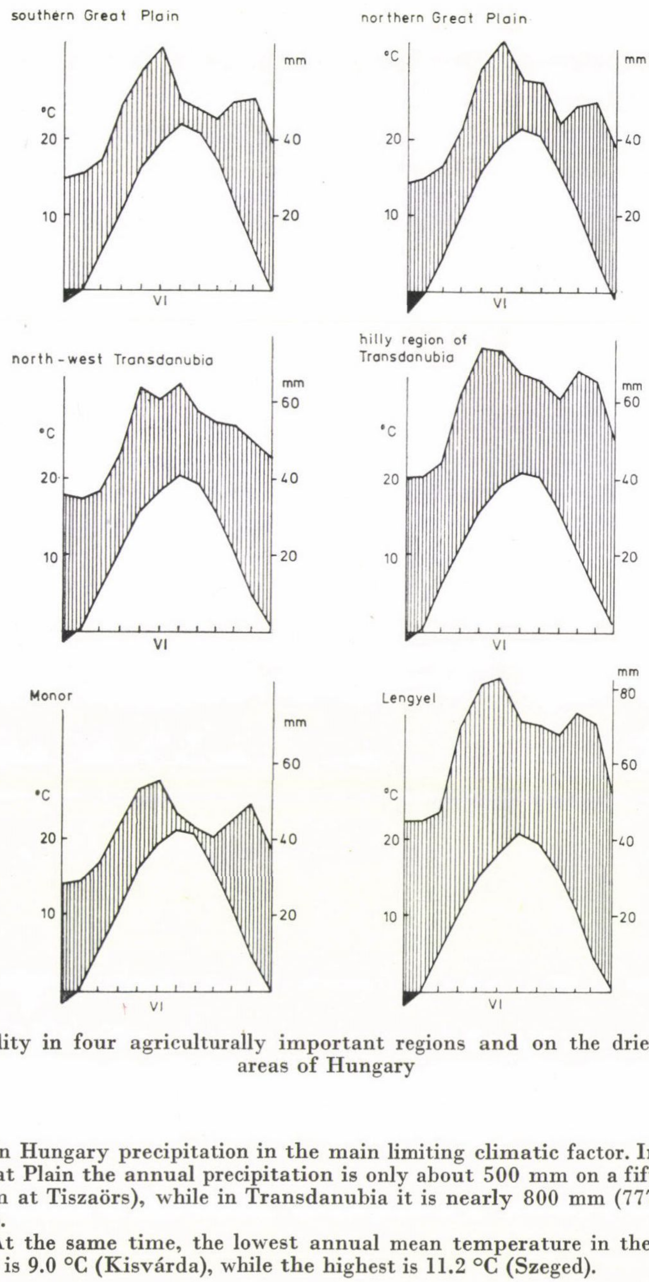


Fig. 1. Humidity in four agriculturally important regions and on the driest and rainiest areas of Hungary

In Hungary precipitation in the main limiting climatic factor. In some parts of the Great Plain the annual precipitation is only about 500 mm on a fifty-year average (510 mm at Tiszaörs), while in Transdanubia it is nearly 800 mm (777 mm at Nagykanizsa).

At the same time, the lowest annual mean temperature in these areas of the country is 9.0 °C (Kisvárda), while the highest is 11.2 °C (Szeged).

KISS, A. S.: Hungary belongs to the conditional irrigation zone, where the amount of irrigation depends on the amount of precipitation. Yet, it is an exception to find a year when irrigation is not needed in one or another period of the growth season, even if the annual amount of precipitation would in fact be sufficient. On considering the summer weather conditions on the Great Hungarian Plain we find that over a twenty year average (1951—1970) 54.5% of them were dry. Consequently, reliable crop production of a high standard definitely requires irrigation. Since the meteorological factors in Hungary show annual, seasonal and regional differences, the extent to which the irrigation capacity is utilized also varies considerably. I should like to remark that irrigation farming must definitely be introduced once dry farming has reached the level where the water supply is the limiting factor.

KOVÁCS, G.: Hungary belongs to the zone where irrigation is conditional on precipitation. Owing to its uneven distribution the amount of precipitation, which ranges between 450 and 750 mm, does not cover the water requirements of agriculture and shows wide fluctuations in the vegetation period, especially on the areas east of the River Tisza, where there is water available. After a long period of observation it can be stated that abundant autumn and winter precipitation is usually followed by a drier summer. No great differences are found in the amount of precipitation. In droughty summers regular irrigation must be applied to obtain 80—100 q/ha of maize, for example. In years with a relatively favourable distribution of precipitation, such as 1978, 50—80 mm irrigation water supplied in August was enough to obtain a 90—110 q/ha grain yield of maize. Thus, the question is, where irrigation should first be developed. Numerous farms in Hungary have almost reached the maximum yield level which can be attained by intensive farming (in the present sense of the word), or under non-irrigated conditions by dry farming. A further reliable, profitable increase in yield can only be ensured by irrigation. In the Agricultural Combinate at Bábolna, for example, where the most up-to-date technical and scientific achievements (varieties, chemicals and implements) have been adopted the only way to achieve a further, economically efficient yield increase is to ensure a reliable water supply. It is not so much irrigation as rational, harmonious water management that is involved here. In modern agriculture irrigation and water management are closely related, inseparable concepts; consequently, the only way to ensure steadily increasing, economically produced yields is, in my opinion, to provide the necessary conditions for proper water management.

KOZMA, E.: Hungary belongs to the zone where irrigation is conditional on precipitation, i.e. where varying amounts of additional irrigation water are required each year in order to obtain high yields. This statement is supported by the following:

In Hungary the distribution of precipitation in space and time shows a highly diversified pattern. On the average of fifty years (1901—1950) the annual amount of precipitation in Transdanubia, with the exception of Mezőföld and Kisalföld (regions in the south-eastern and north-western part of Transdanubia, respectively), is over

	I.	II.	III.	IV.	V.	VI.
						Szentgothárd
Average	39	36	42	59	76	103
Minimum	3	0	2	6	13	27
Maximum	118	153	155	120	185	218
						Győr
Average	36	36	35	46	62	59
Minimum	5	3	0	3	7	1
Maximum	105	112	151	116	207	124
						Szarvas
Average	29	32	33	46	56	59
Minimum	4	1	1	5	8	12
Maximum	89	85	102	111	147	154

600 mm, including the hilly and mountainous areas of Zala county and Western Hungary where it may exceed 700 mm. On the Great Plain, on the other hand, the annual precipitation is 500—550 mm, and in the Kisalföld (North-West Transdanubia) it ranges from 550 to 600 mm. The average values given above do not of course reflect the uneven temporal distribution of precipitation. To illustrate this, the monthly and yearly average and the absolute extreme values of precipitation ore presented using the data series of a number of meteorological stations during the fifty-year period (1901—1950).

The simple series of figures from the above stations also prove that the monthly precipitation showed wide fluctuations in space and time in the period studied; however, it is quite evident that it is not possible to design irrigation systems according to the extreme values.

To decide whether irrigation should become an integral part of the agrotechnics or not in different regions of Hungary, information can be obtained from the formula of climatic water deficiency:

$$H_{\acute{e}} = PE - Cs \qquad (1)$$

where PE represents the potential evapotranspiration, that is the amount of water lost or evaporated under the given atmospheric conditions from a surface well supplied with water. This value, which can be calculated from the meteorological elements, is higher than the water requirements of the plants, since it includes the potential evaporation.

Considering the above, on areas where the value of the climatic water deficiency ($H_{\acute{e}}$) is low, or where water surpluses (negative $H_{\acute{e}}$ values) occur frequently over the years, the establishment of expensive irrigation systems is not economical (e.g. in the western and south-western parts of the country). But wherever the value of climatic water deficiency is regularly high in the vegetation period, as in the Great Plain and Kisalföld (between 300 and 400 mm), irrigation is economical and must therefore become an integral part of the agrotechnics. It should be noted, however, that owing to the uneven distribution of precipitation over the growth season the amount of irrigation water varies from year to year, as shown, for example, by the results of the author's investigations on the irrigation of maize. When expressing the irrigation water requirement as the difference between the water requirement of the plant and the actual amount of precipitation it is found that during the period 1901—1965 there were 16 years in Debrecen, 21 years in Magyaróvár and 46 years in Szombathely when the amount of precipitation during the growth season satisfied or exceeded the water

VII.	VIII.	IX.	X.	XI.	XII.	Year	IV—IX.
104	95	82	69	62	50	817	519
32	16	9	10	8	5	572	300
283	251	214	154	201	138	1125	583
60	56	52	53	49	47	591	335
6	8	2	5	4	5	410	160
194	154	196	145	175	93	971	587
50	50	40	47	48	38	528	301
1	3	3	5	6	9	374	165
161	136	133	156	122	112	895	538

requirement of maize. In the growth seasons of the other years the amount of irrigation water used varied between wide limits at all three stations, and in some years was more than three times the average amount of irrigation water measured over s long period.

To sum up, regular irrigation is worth introducing in Hungary, particularly on the Great Plain and Kisalföld. The capacity of the irrigation system should be planned taking the water requirement of the main crops and the climatic water deficiency into account, but within this the annual amount of irrigation water and the date of irrigation depend greatly on the trend of precipitation and the water content in the root zone.

LELLEY, J.: Hungary belongs to the climatic zone where irrigation is conditional on rainfall, though there are areas on the Great Hungarian Plain where soon it will only be possible to satisfy the increasing yield demands if irrigation gradually becomes an integral part of agrotechnics. And if yield averages must be further increased and stabilized at a still higher level, full supplies of water will have to be provided for on an ever increasing area. It thus depends on the requirements how large an area in Hungary will be included in the zone where irrigation is definitely required. If Hungary's agricultural potential, which may be said to be unique among the countries of Central Europe, is to be rationally exploited, preparations must be made for irrigation wherever it is technically feasible.

LŐRINCZ, J.: It is a well-known fact that Hungary belongs to the zone where irrigation is conditional on precipitation. The amount of irrigation water required to make up for deficiencies of rainfall, so as to attain large yields, varies from year to year. It would, naturally, be favourable if every field could be supplied with irrigation facilities, so that the frequent lack of rainfall could be continuously substituted by irrigation water. In this way regular large yields could be obtained much more reliably. This would, however, be very expensive, and there is nowhere near enough water available to make it possible.

MAÁCZ, J.: There is much food for thought in the practical background of the subject under discussion and the relation of this subject to the "scientia amabilis", in other words, the increasingly efficient positive and/or negative co-operation between practice and scientia naturalis sensu stricto (= ars = Wissenschaft = cognition). In short: do we know what we are doing?

1. The plant and the production model

Figure 1, taken from TIMON, B. (1974): Őszibarack (Peaches). Mezőgazdasági Kiadó, Budapest, 115, shows what false relations are established in agricultural production. Alfalfa, maize or any other plant included in the questions could just as easily be placed in the box representing the controlled system. But does the general character of the model really proves its correctness, i.e. its general validity?

The term "model" might be objected to since in essence it is only a production process figure. This poverty of the models for agricultural production systems, i.e. of the process figures, and the lack of heuristics and intuition (technology → plant → → yield) is particularly noticeable if they are compared with the really great models (e.g. the Carnot machine, Einstein's falling lift) which work even today; in fact, they are more useful than even their creators expected. Owing to the voluntaristic, pragmatic point of view such process figures cannot be used in the natural sciences.

But will it work if it is regarded as a cybernetic model? And if so, with what degree of reliability? Intention and practice can also be included in this model ["Bluffmodellen und Gebrauchsmodellen" by Békésy in LUEKE, B. (1968): Biologische Modelle Bericht über die Jahresversammlung d. D. Akad. d. Naturforscher "Leopoldina", Halle/Saale, 19—22. Okt. 1967. Nat. Wiss. Rundschau, 4, 153—160]. In a target model it is perhaps acceptable for the anthropocentric input block (broken line in the figure) to be treated as "hardware"; for all I know this may be correct in a factory producing fashionable summer textiles. But it is fantastic that the meteorological elements are dismissed to the periphery as "software", or disturbing (!) factors. It is as if the captain of a sailing boat (the cybernetist) were to complain about the sea running high (because the wind was blowing). It is the changing nature and changing intensity of these very elements that carry the plant forward towards the generative stage, towards the goal.

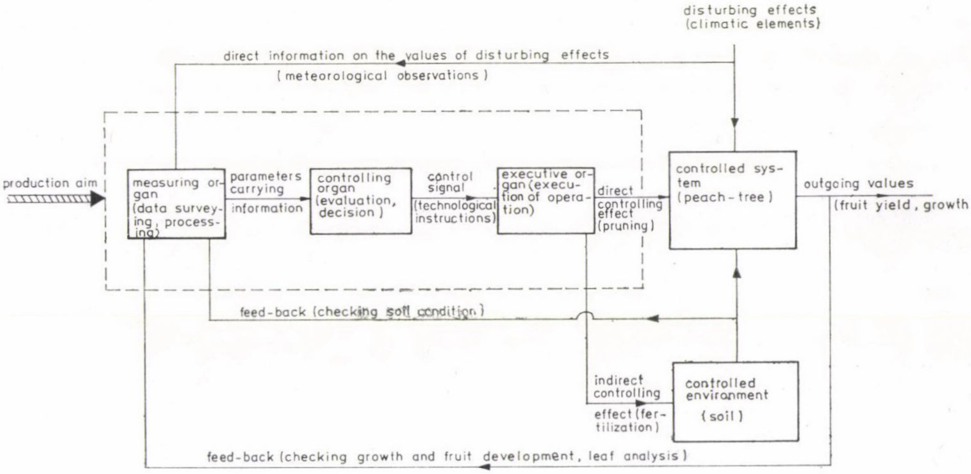


Fig. 1. Model for controlling the production processes of peaches

In spite of the "disturbing factors" the cybernetic model works more or less reliably; in fact, it is almost perfect if it is a matter of broiler chickens or yeast production, for instance. Since I doubt whether cybzrnitics — which is really a mathematical, logical discipline and not a natural science — is able to change the fundamental laws of nature, the model needs verification, that is, the results of direct observation should be substituted into the model: an objective, economic study of the functional limits and the exactness must be carried out. Let us first consider the natural scientific aspects.

2. Symmetry I: translation in space

"A thing is symmetrical if it can be subjected to certain operations, and after the operations it remains exactly the same as it was before" [Feyman, R. P.—Leighton, R. B.—Sands, M. (1970): Mai fizika (Physics for today). 4th ed. Műszaki Könyvkiadó, Budapest, 134]. The variety (cultivar) is only one of the components in the production model. The newer and newer varieties are an integral part of international trade, together with the know-how of their respective growing technologies. The faith in symmetry is almost unbelievable: a variety is sometimes sent to another continent and is expected to be successful in its new growing site (!?). For correct translation every essential component must be maintained (variety + the environment adequate to the genetic code). In the table below the relationship between the relative (alfalfa = 100) transpiration coefficient (a), pH requirement (b) and salt tolerance (c) is shown: (for tabular summary see p. 100).

These are just three of the ecological conditions (the heat, light and water requirements, etc. have been omitted), but it is sufficient to show that there is an enormous chance of breaking the rule of symmetrical translation. All the parameters including those which are as yet unknown !) can hardly be provided. In 1975 Hungarian agriculture attained a national maximum yield of sugar-beet (root): $4 \cdot 10^6$ t, i.e. 32.2 t/ha [Mezőgazdasági Statisztikai Zsebkönyv (Manual of Agricultural Statistics). 1977. Központi Statisztikai Hivatal, Budapest, 71 and 93], and this was coupled with a very small sugar import. The "model" did not work, or more precisely: it was not verifiable.

Beta maritima is native to littoral-maritime sandy soils; it is neither xerophilous, nor positively halophilous, though it is salt tolerant. The osmotic pressure required for water and nutrient uptake is ensured even if there is only a small percentage of sugar. Its immediate relatives (*B. trigyna* and *B. intermedia*, from Asia Minor to the Caucasus) are ± xerophilous with 12—30% sugar [Guyot, A. L. (1942): Origine des plantes

Plant	(a)	(b)[1]	(c)[2]
Sugar-beet	52	5.5–*6.5*–7.5	salt tolerant
Alfalfa	100	6.5–*7.5*–8.5	salt tolerant[3]
Flax	93	— — —	medium
Rye	75	4.1–*5.5*–8	salt tolerant
Potato	78	4.5–*5.3*–8	least salt tolerant

[1] MENGEL, K. (1961): Ernährung und Stoffwechsel der Pflanze. VEB G. Fischer Verl., Jena, 9.

[2] WILSIE, C. P. (1969): A termesztett növények alkalmazkodása és elterjedése a Földön (Crop adaptation and distribution). Mezőgazdasági Kiadó, Budapest, 172.

[3] MÁNDY, GY. (1972): Hogyan jöttek létre kultúrnövényeink? (How did cultivated plants come into existence?). 2nd ed. Mezőgazdasági Kiadó, Budapest, 173–178.

cultivées. Presses Universitaires de France, Paris, 118], so the osmotic pressure is not based on salt accumulation; the active substance is produced by the plant itself.

This positive feed-back capacity is genetically determined in the *Beta* sp. The genetically coded information is concerned with the survival of the species (seed production), not with the interests of the sugar industry.

An abundant water supply acts as a negative feed-back both in sugar-beet and alfalfa.

Medicago sativa is native to arid areas with hot summers; on salty-alkaline soils it has a $\pm$ salt accumulating character (osmosis !). It is a pseudo-xerophyte, able to utilize the water of the subsoil from a depth of 16–20 m [MÁNDY, GY. (1972): Hogyan jöttek létre kultúrnövényeink? (How did cultivated plants come into existence?). 2nd ed. Mezőgazdasági Kiadó, Budapest, 173–178]. The effect of an excessive water supply is seen in poorly developed shallow root systems, i.e. in total defencelessness; in the case of drought and/or technical failure alfalfa is destroyed within 2–3 years on sites where, since Tessedik's successful plantation work in 1979, 10–15 year old alalfa fields have not been rare. Botanically (i.e. from the point of view of the plant) the model is certainly wrong if we plan for 8000 m^3/ha irrigation water, and it is very doubtful whether it is economically verifiable, if the costs and risk of a large hay yield (irrigation equipment, drying plant, deficient seed production, alkalification of the soil) are considered together [MÁNDY, GY. (1974): A bő termés biológiai alapjai (Biological bases of large yields). Mezőgazdasági Kiadó, Budapest, 198].

3. Symmetry II: translation in time

Under the climatic conditions of Hungary an abundant water supply generally prolongs the vegetation period, and a high nitrogen level further increases this effect. The consequences of this must be reckoned with, because in field crops (maize) and fruit production (apples, grapes) the problem of "long vegetation period — early autumn" is more and more frequently encountered at the time of harvesting.

Surplus water undoubtedly increases the heat capacities of the soil and the plant; the temperature of the plant + environment system is further reduced by evapotranspiration. But what effect does this have on the plant . . . ? It is enough to open any book on the subject [e.g. VARGA-HASZONSITS, Z. (1977): Agrometeorológia (Agrometeorology). Mezőgazdasági Kiadó, Budapest, 55–69] and see the large number of arbitrary, estimated, statistically approximated, empirical factors and basic temperatures in the thermodynamical-looking hydric and thermic formulae to realize that there is something (or perhaps many things) that we do not know. The relationship of temperature and water to the rhythm of development and to time (e.g. vernalization) is not clear, and cannot be handled as a question of reaction kinetics. The most serious problem here seems to lie not only in the fact that time is not a thermodynamical property, so that the cross-effects can also be clarified (photoperiodicity, fertilizers, water), but in the lack of knowledge about

a) whether heat just flows through the plant, i.e. it simply ensures a favourable "operative" temperature, or

b) wheter the heat does some work in the system, i.e. whether the heat energy, or at least a Δq amount of it is utilized by the plant. In other words: is the plant able to raise the most degraded energy to a higher level? That is, to what extent is it capable of controlling molecules with statistically disordered kinetic energy, e.g. by means of a Maxwell demon feeding on respiratory energy? or

c) to what extent the plant is able to reduce its internal energy, that is, to do work against a higher environmental temperature.

All three cases postulate a special standard thermometer in the plant, which is hereditary within the variety. Osmotic regulation is also a fact, a hereditary character, and I should not be at all surprised to discover that the removal of excess water took place at the expense of the plant's own energy (point *c*); i.e. it requires work to be done just the same as in animals (kidney, perspiratory glands). In explaining the transpiration descriptions (water transport, root pressure, transpiration suction force, etc.) dominate, but even in the much simpler case of guttation it is impossible to express the process in an exact pV diagram as a function of temperature, i.e. to express the work done by the plant in discharging 1 cm^3 water. Does the plant get rid of the superfluous water by controlling some kind of osmo-receptor system, involving energy input because the high relative humidity prevents it from transpiring? Under less extreme conditions (lower water supply in the soil, drier air) transpiration is probably a spontaneous process (stoma + cuticle), but the opposite may also take place: water deficient plants even near wilting point come to life again in a humid atmosphere [HENDRICKSON, A.H. — VEIHMEYER, F. J. (1929): Irrigation experiments with peaches in California. Cal. Agr. Exp. Sta. Bul., 479]; desert plants and even Hungarian grasses are capable of absorbing water from dew and vapour.

4. The Maupertuis principle

The entropy of the plant constantly increases in its own τ time, even if its direct relation to the temperature ($\Delta S = \Delta Q/T°$) cannot be exactly defined. This is seen particularly in field crops with terminal inflorescence: the death of the vegetative parts begins at the time of flowering. However, the clockwork which is doomed to run down winds up the next one by using external energy. The T time of the species, on the other hand, lasts for millions of years. In less poetic words: the phenotype works irreversibly, but the species is remarkably reversible in its own T time. And this is

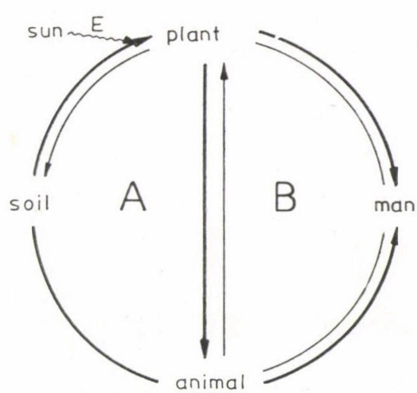


Fig. 2a. The cyclic model

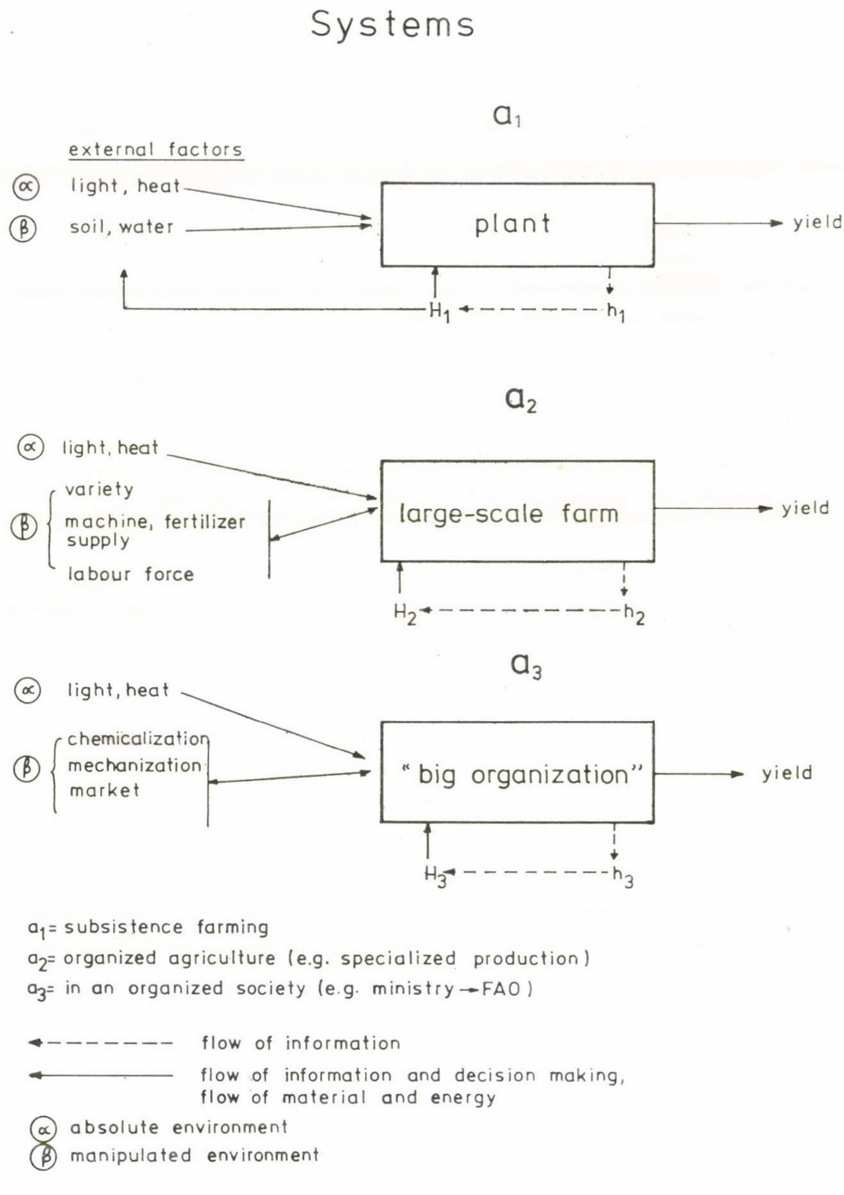


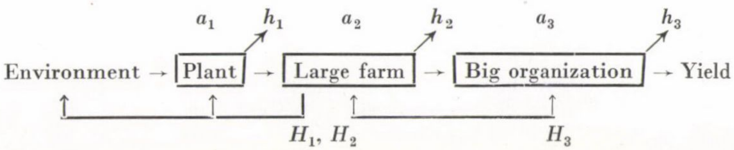
Fig. 2b. The history of agricultural production

precisely what is so worrying: the present cultivars perish within a few years, together with the immense intellectual, material and gene capital invested.

The Maupertuis principle, the principle of the "smallest effect" which is very general in nature, obviously holds true for the phenotype. In the life of the plant the time-metabolism-energy complex is at a minimum. Anthropomorphically expressed: in nature the economical, safe solutions are the successful ones. And this was really so (Fig. 2a); in fact, up to the end of the neolithic age even man was included in the process (Fig. 2b).

This cyclic model broke down irreversibly 8—10 thousand years ago. Man started agricultural production. Homo curiosus (h_1) would just have liked to know more; his clever brother, Homo artifex (H_1), on the other hand, was fond of practical methods; he possessed less curiosity but much greater efficiency. Their progeny first invented scientifically based agriculture (Liebig), then several decades ago brought the "big organizations" into existence, and in the meantime got farther and farther away from each other. In a_3, for example, h_3 is a cybernetist (mathematician) while H_3 is a managing director (with economic views); H_n and h_n have less and less understanding of each other and of plants. In the a_2 system H_2 grows alfalfa and is satisfied when he compares the "yield" (hay, t/ha) to the amount of irrigation water consumed (approx. 0.7 Ft/m^3 $\approx$ $\approx$0.175 kg Diesel oil at the filling station). His colleague H_2' (e.g. a chief accountant) ponders in the meantime over the price and purchasing possibilities of the "high productivity", if possible imported, seed for next year. For H_3, on the other hand, who would convert the alfalfa crop into the form of cheap butter on his table, and who is occupied during the day with the energy problems of a_2 systems + related establishments (drying units, fertilizer factory, sugar factory), the whole thing emerges in the thought that irrigation has fearful energy implications (in 1977 some 700 · 10^6 m^3 water, of which approx. 75% came from sprinkler irrigation, and 1/3 of the 75% evaporated, i.e. 150 · 10^6 m^3 turned into clouds, taking with it some 26.2 thousand tons of fuel).

Summarizing what has been said a model is obtained which is very similar to the first figure but much more correct. The a_n system (all of which tend towards a $\pm$ logarithmic limit value, and the outcomes of which are identical) might just as well be connected:



Or perhaps not, after all?

5. The output: Who has produced it?

We often say that the yield of wheat, maize, etc. is good. Compared to what?, From the point of view of farm management ("not really very much but at a low cost"), or when considered in ton/ha? A great many h_3s all over the world do not believe is this: over the last 50—60 years yields have been doubled, but the costs have risen 5- or even 7-fold. H_2 and H_3 do not give sufficient consideration to energy coming in from outside (sun, oil, coal). What amazes me most is that the starting point for this tremendously wasteful system is the plant, which photosynthesizes with an efficiency of only a few tenths of a per cent. The principle of the smallest effect seems to be the principle of the greatest safety in this case.

The a_1 system processes solar energy and material; the $a_2 \rightarrow a_n$ systems consume a great deal of chemical and electric energy and an increasing amount of information (the latter they are able to produce as well). I think the pride of man the creator: "we have produced it" is justified, but only the output of a_1 is edible.

6. The input: The problem os the sensor

One of the most trivial theses of natural science is: every effect is local. In agricultural production the sensor is the plant itself. Much of this is known by h_1, who even knows that a_1 is constantly sensing and that it reacts in an adequate way: by correcting erroneous signals, eliminating disturbing ones and assimilating the right ones. But not with statistical reliability, because the plant is in a constant state of "hic et nunc": it lives in the present If it makes a mistake it dies.

For the $a_2 \rightarrow a_n$ systems H_n can only intervene after the event, and only then with statistical reliability. He always relies on general (not local) and average data referring to the past (soil map, fertilization and irrigation tables, etc.). In fact, in the possession of long-range meteorological forecasts he even sees into the future (?). Let us look at an example.

In irrigated sugar-beet production some soils give hardly any surplus yield, if at all [BOCZ, E. (1978): Az idényen kívüli öntözés (Irrigation outside the growth season). Mezőgazdasági Kiadó, Budapest, 20]. At the beginning of September H_2 thinks it is time to irrigate as it has not rained for more than three weeks. He therefore orders the minimum 60 mm "precipitation". In accordance with the long-range meteorological forecast rainfall arrives by mid-September, though not the statistically expected 50 mm, but 20 mm more. The experience gained in Hungary shows that September precipitation (x = mm) is of decisive importance for the sugar content (c = sugar % on harvesting): $c = 20.5 - 0.058x$ ($r = 0.86$) [MAGASSY, L.—VUKOV, K. (1977): Cukoripari anyagismeret (Knowledge of raw material in the sugar industry). Tankönyvkiadó, Budapest, "Manuscript" 92]. Thus, an estimation of the sugar content using the equation gives 13% sugar on the, basis of 60 + 70 mm water and 17% without irrigation. The difference is not much, only −40—50 kg sugar, i.e. +40—50 kg water/t. But:

1 t water (= 1 m^3) can be distributed as irrigation with 0.175 kg Diesel oil, while only 0.003 t water approx. 3.2 kg) can be evaporated with the same amount of Diesel oil.

And even this much can only be evaporated theoretically; in practice **it** is much less, owing to operative losses. If similar ratios are assumed for the $4 \cdot 10^6$ t record yield mentioned above, society has had to pay for the transportation and "processing" of at least 200 thousand tons of superfluous water. The problem of transpiration and evaporation is also encountered in fodder processing, maize harvesting, vegetable production (drying) and condensating fruit-juice. The problem has a serious energetical background extending beyond national borders and beyond the scope of plant physiology: it is of social significance.

This puts me in mind of another basic principle: the principle of evading pressure. Why does the plant not possess the same ability for rejecting surplus water as it has for example, in the case of Na and certain cations and anions? Or are the reduced root-system, the thinner root hair and the intensive transpiration manifestations of the Chatelier principles? May be better products could be produced at lower cost and more reliably if, instead of establishing "optimum" (apodictical) water norms, the "feeling of comfort" of the plant were reconciled with the social profit.

7. Environment and the third cybernetist

The New World was reached by the Santa Maria, and also by the Queen Elizabeth. The Santa Maria would still get there today, but the latter might easily become shore-bound because of an unexpected dock strike or an oil shortage; the former is not affected by the oil crisis. One of them stops when the wind does not blow, while this is favourable for the other. The two captains have only one common problem: neither of them has any influence on the environment, they encounter unchangeable obstacles. Accepting this most general definition of the environment [CHURCHMAN, C. W. (1977): Rendszerszemlélet (The systems approach). 2nd ed. Statisztikai Kiadó Vállalat, Budapest, 40—47], the two captains will obviously mean something quite different by "environment". And the environment really is different. Apart from the definition only the destination is the same.

The captain of the Queen Elizabeth takes with him problems from a land or even urban environment: Passengers, crew, apartments, air conditioning, heating, illumination, etc. His task is to preserve the stability of the system and reach his destination in the shortest possible time. He cannot eliminate the disturbing external factors (meteorological elements, icebergs, etc.) since these are the environment, but with his vast, though limited, energy resources and his technical expertise he ± excludes or avoids them. Unexpected transient phenomena which do not affect the main issue (destination) may also cause irreversible damage, e.g. a short power cut: panic, radar → → iceberg. It is possible to recognize Fig. 1, the vulnerability of the system, the broiler and bacon plants. Homo artifex from one of the a_n systems, who overcomes nature.

The captain of the Santa Maria, on the other hand, makes use of the situation and decides "hic et nunc". Realizing that he cannot influence the environment, but recognizing the possibilities hidden in the limiting factors, he makes use of the knowledge

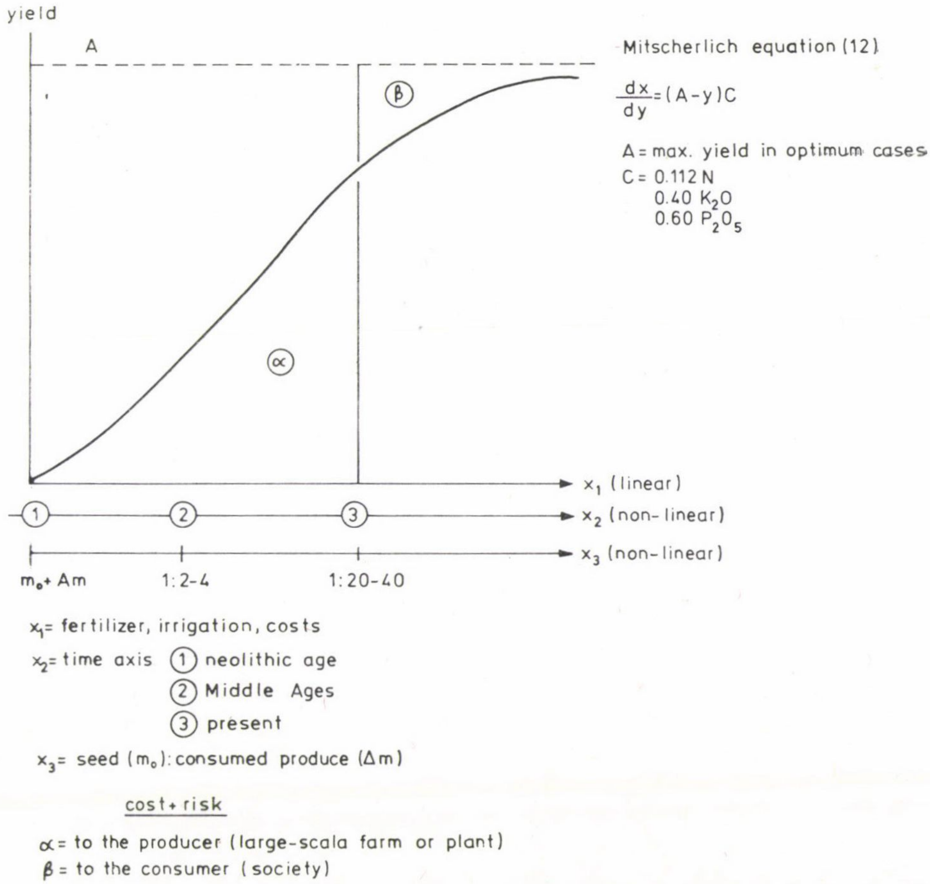


Fig. 3. The Mitscherlich curve

coded in his memory, and with the use of external energy which is continually regenerated he finally reaches his destination. He stores knowledge instead of energy carriers. Maupertuis would give the Blue Ribbon to him: to the a_1 system. (Fig 2a, b).

The competition between ships has come to an end; more than a hundred years have passed since the clipper outsailed the steamer. In agriculture this cannot happen. We cannot go back to the neolithic age: four thousand million hungry mouths would protest loudly, and some little-h or other less loudly: biological processes are irreversible even in the big-τ.

The third captain raises the principle of "highest profit — lowest risk": I cannot dispense with the sail, but at least in periods of calm I will turn the engines on. In Fig. 3 the good old Mitscherlich curve is seen with some minor additions. The costs of production steadily increase (X_1 = fertilizer, mechanized work, water, etc.), and beyond a certain point business management considerations do not make it worth attempting to increase the output; as we approach the genetically attainable limit (A) y will give less and less response to an increase in $X_1 : \frac{dx}{dy} \rightarrow 0$. $H_2 \rightarrow H_n$, on the other hand, finds that the larger are the investments he makes, and the higher yielding are the varieties he grows, the more the production will fluctuate. To this, h_3 (the cybernetist) replies: this is quite natural, forced systems are vulnerable. The risk is proportionate to the area bordered by the ordinate rather than to its height. Reducing the social and consumer risks to a minimum will not increase the costs of the a_2 system indefinitely. The Earth cannot be converted into a greenhouse. In passing: the difference between the two views is clearly seen here. The greater the surprise, the greater the discovery = this is little-h. On the other hand, the greater the surprise, the greater the risk = this is big-H. He is evidently searching for maximum stability.)

Risk and stability apply to the a_1 system as well. If on the non-linear X_2 time axis the seed : yield ratios are also indicated their rapid growth will cause quite a surprise. Ten thousand years ago the only aim of the plant in producing $m_0 + \Delta m$ seed was survival and perhaps the spread of the species (Δm became an ancestor at the most). After a relatively short time (even in comparison to the T time of man) this ratio became 1 : 2—4 in the Middle Ages, while today even a 1 : 20—40 ratio is not infrequent. The diversity in the genetic protocol of the original a_1 system strictly corresponds to the diversity of the environment and to the basic rule of control: only diversity can wipe out diversity [Ashby, W. R. (1972): Bevezetés a kibernetikába (An introduction to cybernetics). Akadémiai Kiadó, Budapest, 244]. However, with a view to fitting the a_1—a_2 systems as perfectly as possible, the breeder crossed out the "superfluous" text in the protocol, and is therefore compelled to reduce the diversity of the environment as well.

For numerous plants and fruit-trees Hungary has the best soil and climatic conditions in Central Europe. But the competition between more and more intensive varieties and more and more specific ecological requirements cannot last for ever. The views expressed by the third captain are the most realistic. Hungary belongs to the zone where irrigation is conditional on precipitation. There is only a real drought in 1 out of 10 years. It is enough if we give the plant minimum support, without wishing to play the role of Providence, because our energy resources are not unrestricted. The fact that we cannot see into the future is proved by the "by-products" of our farming activity: all over the world there is gene erosion, laterite, desert and alkali soils, depending on the climatic zone, and a high nitrate content in the water and in juicy fruits.

According to our present knowledge agriculture will never become a factory, nor will it produce industrial products. The produces of agriculture are edible, and their prices at a given time (the last piece of bread) are not the subject of debate or a question of agreement.

At present only the plant is able to transform the energy of the Sun into chemical (edible) energy for us. It is the plant that connects us with the Sun, so it is a transformer and regulator of our cosmic environment. We are parts of a system which is much larger than we are, and — as Aristoteles said — pars non supra totum (the part is not superior to the whole).

Mihályfalvy, I.: Hungary belongs to the zone where irrigation is conditional on precipitation, that is, varying amounts of irrigation water, depending on the amount and distribution of precipitation during the growth season, have to be supplied each year to satisfy the water requirements of the plants. In order to attain reliable large yields and eliminate serious fluctuations, irrigation should tend to become an integral part of the agrotechnics, particularly in the case of crops with high production values (e.g. horticultural plants).

The necessity of irrigation is basically determined by the climate, the water requirement of the crop, the intensity of this requirement, the water balance of the soil and the depth of the ground-water. The larger the yields harvested, the more dominant the role of water, as a minimizing factor, will become. On the basis of results achieved over several years of irrigation farming, it was reasonable at the beginning (in the 1950s) to make the prevention of drought damage and a steady yield level the aims of irrigation, while now irrigation is aimed mainly at increasing average yields.

Németh, S.: Owing to the climatic, and particularly the precipitation conditions in Hungary, the annual amount of rainfall undoubtedly shows extremely wide fluctuations, ranging from 400 to nearly 1000 mm in certain parts of the Great Plain. This is why Hungary should be placed in the zone where irrigation is conditional on precipitation, since irrigation is not needed every year, nor regularly throughout the vegetation period, and the annual irrigation water requirement varies from year to year in accordance with the actual amount of precipitation.

As to the second part of the question I should like to emphasize that although irrigation is an inseparable part of the agrotechnics in modern irrigation farming, owing to the precipitation conditions in Hungary, if irrigation is to be efficient, water management must be given priority on the irrigation areas.

PÁSZTOR, K.: In my opinion water management, including irrigation, should become an integral part of the agrotechnics on areas where intensive crop production is carried on and plants responsive to irrigation can be economically grown.

Under the conditions of Hungary (with a latitude of 45—48° north) approx. 240—250 q/ha aboveground dry matter can be produced with optimum radiation, as shown by F. Beke.

At the same time the average heat conditions make the production of 200—220 q/ha dry matter possible. The available water (on the basis of average data over many years) is only sufficient to produce about 140 q/ha dry matter. So the exploitation of the optimum light and heat conditions would require 630 mm precipitation which in most cases is not available.

Hungary falls within the zone where irrigation is conditional on precipitation. In some years water is at a minimum compared to the heat and light conditions. Irrigation is a rather expensive investment, so it must not be developed faster than the rate at which the conditions for efficient exploitation of the irrigation water can be established.

As long as the genetically determined production potential of the commercially grown varieties is, according to the results of relevant surveys, exploited only to 66.7% in wheat, 52.3% in maize, 36.0% in grasses, 37.5% in grapes, 55.0% in potato and 54.0% in sugar-beet on a national average, the absence of irrigation is not the only factor limiting the yield increase.

Investigations and practical experience show that 60 q/ha of wheat and 90—100 q/ha of maize can be produced even under dry farming conditions. If larger yields are to be attained irrigation must be included in the long-term plans, but as a first step conditions should be created under which the highly expensive investment will increase the economic efficiency of production.

PETRASOVITS, I.: The "zone where irrigation is conditional" is basically a climatic term. It means that in some years the natural precipitation is sufficient, while in others it does not cover the full water requirements of the plant stands. That is, irrigation is not needed every year.

The answer to the question depends, however, on the species and varieties which are given priority for ecological and economic reasons when it comes to satisfying water demands.

To decide which these species and varieties should be, it is necessary to determine the "irrigation demand index" established and applied by the author. This index shows the ratio of irrigation water requirement to the full water demand of the crop. Its value is less than 1 in most parts of the world. However, the closer it is to 1, the higher the need for irrigation. The value of the index depends on the crop, year, soil, water conditions, intensity of precipitation, etc.

On the basis of our investigations I am of the opinion that wherever the average value of the irrigation demand index is higher than 0.3—0.4, i.e. 30—40% of the full water demand of the crops during the growth season must be satisfied by irrigation, irrigation should be made an integral part of the production technology and carried out according to the actual precipitation conditions. The limits may vary according to the crop and the economic conditions. In certain cases, however, for example when starter irrigation or atmospheric irrigation is thought to be justified, the partial irrigation demand index may be of use. In this case the value of the index is determined not for the whole growth season, but only for a particular period — the phenophase of sprouting or fruit formation, etc.

PLETSER, J.: According to Borghesani irrigation is necessary in regions with an annual precipitation of 350—500 mm and supplementary irrigation is needed at sites where the the annual amount of precipitation is 500—700 mm. Considering that only about 60% of annual amount of precipitation falls during the growth season, agriculture in Hungary cannot be carried out without irrigation. It is thus desirable to introduce irrigation farming in all places where irrigation water is available and the soil conditions are suitable. The method, time, rate and frequency of irrigation should be adjusted to the crop, soil and weather so as to produce the planned yield surplus at the lowest possible cost. The amount of irrigation water should be determined according to the water demand of the cultivated crop. The topsoil should not be saturated to full water capacity lest rainfall after the irrigation should cause leaching of the nutrients. Irrigation must become an integral part of the production technology.

POSGAY, E.: It is an established fact that Hungary is situated in the zone where irrigation is conditional, which means that the demand for irrigation water varies from year to year, and the time of irrigation also changes. The total amount of precipitation during the vegetation period does not in itself give reliable information about the necessity of irrigation, because it frequently occurs that while the total amount of precipitation would cover the water requirements, certain periods within the growth season are so dry that irrigation is still needed.

If this question is examined in relation to particular soils and crops it is found that irrigation is needed less frequently on soils with a thick layer of top soil and for crops with deep roots, and more frequently in the case of soils with a thin layer of top soil and for shallow rooted crops sensitive to drought (e.g. certain vegetables).

Independently of this, on areas equipped with irrigation facilities irrigation should become an integral part of the agrotechnics, since the possibility of supplying water is not the only difference between irrigation farming and dry farming: with a favourable water supply (through irrigation or natural precipitation) different amounts of nutrients, different spacing, etc. are required to obtain maximum yields than when water resources are limited. Hence, on areas equipped with irrigation systems irrigated agrotechnics must definitely be applied even if in some years a favourable water supply is provided naturally, without irrigation.

POZSÁR, B.: The annual average amount of precipitation is indicative of a semiarid character, and since the distribution of precipitation during the growth season is not uniform, this circumstance is an obstacle to the planned large yields. In my opinion, instead of replacing the missing amount of precipitation the water content of the soil should be preserved, e.g. by using mulch type materials.

SHMILLIÁR, M.: On the overwhelming part of the area suitable for agricultural production in Hungary irrigation should become an integral part of the agrotechnics. Soil moisture should be kept at a level optimum for life in the soil. Water absorbed and transpired by the plants and evaporated in other ways should automatically be replaced. Constant attention should be given to the water regime of the soil. Ideal water management can only be solved on areas which form a hydrogeographic unit. I am thinking here of the catchment area of a river, or of areas surrounding a low-lying area. Simple drainage may result in some increase in the cultivation area, but if water is drained off a large area it lowers the ground-water level so much that in the case of drought successful agricultural production becomes dubious. On these areas artificial reservoirs should be established which render rational water management possible. With this solution the biological balance can also be maintained, and it is better from the point of view of environmental protection. Soils exposed to erosion by the wind are also protected better than with other methods.

SOMOS, A.: Different plants give different responses to irrigation. This, together with the value of the crop, influences the economic efficiency of irrigation in different ways; there may be substantial differences in the degree of efficiency, and it may happen that irrigation is not economical at all.

In my opinion, wherever it is profitable at a national economic level it is worth introducing irrigation and making it an organic part of the agrotechnics, though only if a technology based on exact methods is used to satisfy the water requirements of the plants. Hence, the amount of water used for irrigation necessarily varies from year to year, chiefly according to the amount of precipitation. Consequently, the fact that Hungary belongs to the zone where irrigation is conditional on precipitation does not exclude irrigation from forming an integral part of the agrotechnics in the case of certain plants (e.g. paprika, cabbages).

SZABÓ, B.: In my opinion, as regards the amount of precipitation, Hungary should be divided into two parts: west and east of the Danube, respectively. The western side, Transdanubia, is richer in precipitation; in practice it belongs to the zone where irrigation is conditional on precipitation. The eastern side is a drier, droughtier region where irrigation should be regarded as, or made into an integral part of the agrotechnics.

In this part of the country temporary droughts regularly occur in the growth season, which means that the crops suffer from a greater or lesser water deficiency during the vegetation period.

This is why irrigation should form an integral part of the agrotechnics, i.e. the production technology must be designed to include irrigation. The production systems would also be justified in giving this subject thorough consideration.

The permanent high costs of modern irrigation systems virtually force the farms, quite rightly, to make the most efficient use of this yield-increasing factor.

The disadvantage of this situation is that farms with large, well-equipped irrigation areas have had very little opportunity to gain experience in how to use this equipment. Arrangements should have been made for them to gain experience, possibly abroad.

A similar stituation arose when choosing the type of irrigation machinery; this is obviously why there is such a wide range of irrigation machinery in Hungary.

The above causes explain, in my opinion, why the belowground delivery pipe irrigation plants completed in 1974—75 are not operating satisfactorily and are not as efficient as they were rightly expected to be.

On the whole, I am of the opinion that in the region east of the Danube irrigation should be an essential element of the technological planning work.

Szabó, L. Gy.: The importance of irrigation will increase in the future all over the world, and the natural, economic and biological problems connected with this will multiply. Two general aspects should be emphasized here: environmental protection and the expected change in the climate of the Earth.

It is a well-known fact, though it must be mentioned to clarify my train of thoughts, that irrigation is determined primarily by the natural conditions and by the biological nature of the crop to be irrigated. The economic possibilities are also important, of course, since it is a question of human activity. As to the natural conditions, it is essential to keep the soil and natural waters in the best possible condition, as major human interference may cause irreparable damage in the agrobiocenosis (e.g. the consequences of drainage, deforestation, alkalization, etc.). The quality of the irrigation water is threatened by pesticides and their decomposition products, and by other compounds seeping from the soil into the water, which often cause damage to plants when they enter the soil. Thus, the quality of the irrigation water should be ensured by planned technological operations.

Although, opinions on climatic changes differ, it must be emphasized that a period of cooling down, or a rise in temperature due to an increase in the carbon dioxide content of the air may cause unexpected changes not only on the Earth in general but also in the climatic conditions of smaller regional units (e.g. in the vicinity of industrial centres and sources of air pollution the precipitation maxima are higher). So environmental protection measures may indirectly decide the necessity of irrigation or promote its efficiency.

The environmental conditions and the activity of man must be co-ordinated so as to ensure the full biological requirements of the given crop. It follows that the biological nature of all cultivated plant species must be thoroughly known. This sounds like a truism, yet it must be emphasized, since we are far from knowing all the biological aspects of our cultivated plants. For example, hardly anything is known about the polyfactorial transmission and exact biochemical explanation of drought tolerance.

The genetic properties of the varieties must be known just as much as the ecological demands characteristic of the variety. Both now and in the future a continual increase in productivity is expected from the varieties and hybrids; record must follow record.

However, a more realistic objective for plant breeders all over the world is to endeavour to achieve yield stability, which is necessitated by the extremities of the weather. In my opinion the necessity and programming of irrigation must be decided from this point of view. If the particular demands of a plant species or variety are known (and it is not enough to consider the water demand alone!), then irrigation will be carried out wherever possible during the vegetation period.

From the point of view of plant physiology a lot of question may arise. One of the most important, in my opinion, is that solutions must be found for increasing the water capacity of the soil or retaining its water content (e.g. by applying synthetic resins, humic acid derivatives, plastic covers, etc.), or else for increasing the water retention of the variety genetically by exogenous or endogenous means without reducing the organic matter production.

Here again, the ecological demands of the varieties should be known in order to be able to plan the agrotechnical operations and any necessary irrigation. Mándy's phenoecological method appears to be an excellent way of examination. The complex survey and analysis of phenological and meteorological data, based on fractional sowing, makes it possible to determine the quality, sensitivity, productivity and stability of a variety.

Our own investigations are aimed at demonstrating the different germination characteristics of the varieties. The initial phase of ontogeny is decisive, and the ecological requirements of germination must be precisely known. From the point of view of plant breeding, germination studies concerning salt tolerance and osmotic pressure are useful, as they provide basic information on drought resistance in the varieties or lines. As I mentioned above, with a view to increasing yield stability, selection for drought resistance is justified in a large proportion of field crops in Hungary. Germination tests are a great help in this respect.

The germination characteristics of seeds are studied using different osmotic solutions, of which polyethylene glycol (PEG), mannitol and various salt solutions are the best known.

Seed treatment with salt solutions is advantageous due to the fact that inorganic salts have a characteristic ion action besides exercising an osmotic effect on the seed.

It is very important to find ways of increasing the germinative ability under field conditions and of reducing the length of the germination period, especially in the case of cold soils. At low temperatures a previous treatment with an osmotic solution provides important information on the viability of the species or variety.

Laboratory analyses have recently been extended to include tests simulating natural conditions: cold test germination, warm test germination, tetrazolium germination, accelerated aging germination. The vigour indices obtained with these tests render a correct evaluation possible and agree approximately with the values characteristic of field germination. Such tests should be elaborated for every crop so as to characterize the seed vigour both by these and other tests and by treatment with osmotic solutions and inorganic salt solutions.

Polyethylene glycol (in general PEG 6000) is the most frequently used osmotic solution. The pressure balance for the germinating seed, which is usually given as the osmotic potential level, can be expressed as follows:

$$\begin{array}{c}\text{Sum of the soil}\\ \text{water potential}\\ \text{components}\end{array} + \begin{array}{c}\text{Osmotic potential}\\ \text{of the seed}\end{array} + \begin{array}{c}\text{Cell wall pressure}\\ \text{of the seed}\end{array} + \begin{array}{c}\text{Normal stress in}\\ \text{the soil}\end{array} = 0$$

The osmotic pressure (expressed in bar or atm.) is a value characteristic of the species and even of the variety. A good example of this is the experimental result obtained by Muchena and Grogan, according to which the seed of the drought resistant maize variety White Cloud germinated relatively well even when treated with an 18 atm mannitol solution, in contrast to the seed of lines derived from the variety, whose germinative ability was reduced almost to zero at 14 atm. They also found that under the influence of simulated moisture stress small seed germinated better, that is, they were capable of exercising a higher counter-pressure against the applied pressure of 10, 14 and 18 atm.

In germination tests carried out with various cultivated plants (triticale, rye, wheat, rice, millet, Setaria italica, common vetch, saintfoin, clovers, etc.) it was found that 0.5—3% solutions of sodium, potassium and calcium chloride provided useful information concerning the characterization of varieties. Of the plants examined, soybean is particularly interesting from the point of view of irrigation. It can be seen in Table 1 that considerable differences were found between the varieties as regards salt tolerance. Of the varieties examined Norchief, Clay, G.Sz.3 and Altona showed the highest tolerance to a 2% solution of NaCl, while Morsoy, Korona and Ottawa were the most sensitive. The general sensitivity of the varieties Morsoy and Ottawa is proved by the fact even the 2% KCl treatment, which was the least harmful, resulted in a considerable reduction in germination.

As a consequence of treatments with mannitol solutions with various osmotic pressure (6×20 seeds in a Petri-dish given 20 ml solution on one occasion and germinated at 20 °C) the rate of germination of soybeans slows down. At a concentration corresponding to 10 atm the germination period becomes 7—10 days longer; in spite of this the

Table 1

Effect of salt solutions on the germination of soybean varieties at 20 °C

Varieties	Control	Germination percentage								
		NaCl			KCl			$CaCl_2$		
		1	2	3	1	2	3	1	2	3
Altona	94	90	54	0	90	89	42	81	76	41
Clay	100	100	71	0	100	90	77	100	94	15
G.Sz.3	100	100	56	0	100	96	70	100	99	44
I.Sz.1	97	95	34	0	97	94	67	96	81	52
I.Sz.7	100	96	41	0	99	95	24	95	83	30
Korona	99	96	19	0	97	89	29	99	81	42
Morsoy	97	87	6	0	96	74	32	95	53	11
Norchief	100	100	76	0	100	100	44	100	91	16
Ottawa	98	90	29	0	97	79	38	96	84	40
Traverse	100	96	45	0	95	84	4	91	72	9
Varietal mean	99	95	43	0	98	90	43	95	81	30

Table 2

Effect of a mannitol solution with an osmotic pressure of 15 atm on germination in some soybean varieties

Varieties		Appearance of radicle on the 4th	5th	6th	7th day of germination	Total after 14 days
Altona	control	75	76	84	90	94
	treated	0	4	8	28	61
Clay	control	92	94	96	96	96
	treated	0	15	53	74	80
Evans	control	58	60	64	68	72
	treated	0	0	12	44	64
I.Sz.10.	control	84	84	90	90	90
	treated	0	26	70	84	88
Merit	control	60	62	66	68	71
	treated	0	0	20	68	70
Traverse	control	66	68	78	80	80
	treated	0	0	28	56	80
Wilkin	control	84	85	86	86	86
	treated	0	2	38	76	84

germination percentage reaches a maximum (96%). At 15 atm the germination percentage decreases (90%), and the development of the germ stops. Although, the radicle evolves there is hardly any elongation of the hypocotyl and the lateral root primordia do not continue to grow. From seeds germinated in this way normal seedlings only develop if they are transferred to an optimum medium. At 20 atm the germination is 25—30%, and the radicle and hypocotyl grow very slowly; even if they are transferred to a suitable germinating medium the seedlings rarely show normal development. In variety trials a concentration of 15 atm was used (Table 2). It can be seen that there are differences between the varieties in the date at which germination begins and in the rate at which it proceeds. The Hungarian bred variety I.Sz.10 (Research Institute for Fodder Production, Iregszemcse) and the American variety Clay were the first to germinate. Altona and Evans were found to be the most sensitive.

Of course, these simple pilot studies can only give useful information if the origin of the variety is known. The values characteristic of the variety change, because the variety itself may change (degeneration), and because a lower yield and poorer quality seed may be obtained as a result of unfavourable conditions (agrotechnics, soil, weather, etc.). Such seed is more sensitive to the effect of osmotic solutions too. It is therefore advisable to examine seeds from a number of places every year, thus drawing conclusions on the value of the variety, line or breeding stock.

SZALAI, GY.: I think that from the point of view of irrigation requirements, the plants, or groups of plants, grown in Hungary should be judged differently: winter cereals, and crops sown in spring and harvested in autumn (maize, sugar-beet), should definitely be placed in separate categories.

Winter cereals utilize the winter precipitation, which is generally considerable, extremely well. Consequently, the usual amounts of precipitation in spring and during June are not of great importance, as proved by the data obtained in the course of research on the methodology of crop estimation, which generally show a low correlation between the yields of both winter wheat and winter barley and the amount of precipitation in the months in question. It was only in the drier and warmer regions (central Great Plain) that a medium close correlation (0.5—0.55) was found between the yield average and the total amount of precipitation in these months. On this basis it can be said that in most years the amount of water in Hungary is sufficient to enable winter cereals to produce large yields (60—70 q/ha). (Here the movement of water in the soil must also be taken into account, since the ground-water level rises in dry winters as well.) Irrigation in winter cereals is therefore only useful in exceptional cases. And even then, a reservoir type of irrigation, depending on the water content of the soil in spring, will be the most important, though irrigation in the autumn to help sprouting may also be needed. At this point it should be noted that on the Great Plain and in the drier parts of Transdanubia the amount of precipitation in September and October is in medium, or sometimes close, correlation with the yield averages of winter cereals in the following year.

For maize and sugar-beet the total amount of precipitation in the summer months is of great importance. In developing a complete stand the role of April and May rains cannot be ignored either. Precipitation during the vegetation period, even if it exceeds the average, is no guarantee of a good yield, because even in this case droughty periods of some length may still occur. Therefore, with a view to attaining reliable large yields with these crops, irrigation must become an integral part of the agrotechnics. It must be emphasized, however, that the irrigation should be differentiated depending on the crop year rather than being a routine water supply if real success is to be achieved.

SZALÓKI, S.: Hungary belongs to the zone where irrigation is conditional on precipitation, since irrigation is not an indispensable condition of agricultural production; that is, agricultural production can be successful without irrigation.

It is true, however, that on a large proportion of the agricultural area of Hungary irrigation is an important precondition for attaining reliable high yields in most crops. Consequently, wherever irrigation farming is introduced, irrigation must become an integral part of the agrotechnics.

SZIKI, G.: Prior to answering the question itself I should like to discuss the validity and applicability of the concept of "zones of conditional and unconditional irrigation". The concept may occasionally be useful, but only as a rough approximation, as it refers to only one of the numerous production factors: the amount and distribution of precipitation. But even this is far from being of general validity, since the water demand of the plant in question is decisive. Rice may be mentioned as an extreme example. Under the climatic conditions of Hungary rice can only be grown with the help of irrigation, so from the point of view of this crop Hungary belongs to the zone where irrigation is definitely necessary. But in addition to the plant species and the natural factors, a number of economic factors, e.g. yield stability, economic efficiency, also modify the somewhat vague definition of the zones. It is a well-known fact, for example, that a number of vegetables with a large water requirement can be grown without irrigation, though in this case the production will be highly unreliable and the yield low. Since the production requires substantial investments the risk cannot be tolerated. The low yield will not cover the investments and this will imposes restrictions on the production. This is the major reason for the failure to carry out the "vegetable programme". Sufficiently reliable vegetable production which will cover the investments and give a profit can only be carried out with the help of irrigation. In other words, owing to the objective effect of the economic factors, irrigation is a basic condition for production. It can thus be said that with regard to a number of vegetable crops Hungary falls within the zone where irrigation is definitely required.

At first sight the above reasoning could be refuted, and the opposite could also be "proved".

The crop production systems apparently offer a good example of this. Two decades ago very few people believed that the yield of maize, for example, could be increased threefold without irrigation. Today, however, it is an established fact, which can be ascribed to the optimum or near optimum supply and co-ordination of production factors.

All this seems to prove that irrigation is not an indispensable condition for an intensive increase in yield. And at the current stage of development, when reserves are still available, this is in fact true, so much so that many experts have been misled, as is proved by the fact that in the technological rules for the crop production systems, with the exception of the Nádudvar Union for Large-Scale Maize Production, irrigation is not even mentioned. (Complex water management aimed at ensuring optimum water conditions for the area is not found in any of them.) The use of nutrients and the current cultural practices seem to have solved the problem. But this is only true up to a certain limit, and in some places this limit has almost been reached. What will cause the rude awakening is the optimum supply of well co-ordinated production factors, which is responsible for the current rate and extent of production increase, which has never before been experienced. So far, and up to a certain limit in the future, sufficient "water supply reserves" have been available to allow an optimum combination of other factors to produce a rapid increase in yield. However, once the other factors reach a level even higher than the present one, the amount of water available from natural precipitation will be insufficient to produce a further increase in yield, so progress will be checked. The obstacle to progress is to be found in the moving force of the development, in the optimum co-ordination of production factors: there will be too little of one of them — water. And this will eliminate or at least reduce the effects of the other factors. A continuous increase in yields is a biological, economic, etc. necessity, and will be impossible beyond a certain limit without artificial water supplies, i.e. irrigation. This limit will first be reached, parallel with the rise in the production level, in the most developed systems.

Irrigation becomes a precondition not only for progress but also for maintaining economical production at the current level. It might be said that beyond a certain stage of development Hungary will belong to the zone where irrigation is definitely required for maize production too.

The same holds for a number of other plants.

On the basis of the above it is easy to give a short answer:

In high level crop production irrigation must become an integral part of the agrotechnics beyond a certain stage of development. It is up to the experts to determine where and when this stage is reached.

Tóth, M.: In Hungary there are rainfall variations between crop years and between various regions of the country of as much as 100%, in spite of the fact that the total area of the country is not more than a hundred thousand square kilometres.

Hungary belongs to the zone where irrigation is conditional on precipitation, but the term must be correctly interpreted. A great number of plant species can be successfully grown without irrigation, but the natural water conditions limit the yield, and fluctuations in yield can be expected. At a higher yield level and with more intensive production the economic consequences of annual fluctuations in yield become more and more serious. It is thus obvious that the improvement of water management through the development of irrigation is a precondition for a steadily high level of production in Hungary.

Wherever irrigation is introduced it most be an integral part of the agrotechnical system, but it would be both economically and biologically harmful to supply the same amount of water every year. Hence, an effort is made to stabilize the yield at the planned high level by applying irrigation water in quantities varying from year to year according to the natural water conditions.

TUKÁCS, O.: The territory of Hungary, as seen from the data presented in the question, belongs to the continental climatic zone where the amount of precipitation is varies considerably in space and time. The uneven, or in some years extreme, distribution of precipitation is one of the characteristic features of this zone. Irrigation is thus a precondition for reliable production in this area.

Irrigation may have several purposes. With agricultural and horticultural crops the aim is to obtain larger yields, i.e. to increase the volume of production. However, irrigation not only promotes an increase in yield very efficiently, but also has a considerable effect on the environment. The effect of irrigation on the immediate human environment is of particular importance. In this case irrigation is aimed at conditioning the environment, improving the micro- and macroclimate of man's immediate surroundings and making them more comfortable.

In agriculture the primary task of irrigation is to increase the yield. Production reliability requires water to be supplied in due time at rates corresponding to the requirements of the plants. In field crop production where the vegetation period is generally less than a year, the yield is measured, i.e. the success of irrigation is checked, on the basis of a single crop harvest. In the case of meadow and pasture management the yield is measured by totalling the results of repeated cutting and harvesting, as in the case of fruit and vine growing and perennial horticultural crops. The absence of irrigation (for lack of the necessary technical or other conditions) does not involve the same risk in each of the crops mentioned. In agricultural crops with shorter vegetation periods the risk is generally not so great as in the case of the more valuable horticultural crops or with perennial crops. In the latter case the yield of not only the current year but also of the following year may be jeopardized, or the whole crop may be destroyed by a lasting drought.

In agriculture irrigation must be considered from the point of view of the conditions, not only from that of the requirements. Sufficient amounts of water suitable for irrigation are needed, together with appropriate technical and biological material (plant varieties suitable for irrigation) and economical operation.

On the above grounds irrigation in Hungary is at present conditional on precipitation. Later, if the right financial, technical and biological background is provided, irrigation may become an integral part of the agrotechnics.

The other aim of irrigation is the conditioning of the environment. Very little attention has been paid to this so far. Although, it has lately come to the fore, along with the avoidance, reduction or elimination of harmful environmental effects, I think less than sufficient emphasis is laid on it. For the time being water management is concerned mainly with the protection of water quality and little control is exercised over the rational use of water.

In this case the so-called green surfaces are irrigated. The green areas of cities are those elements of the landscape which penetrate into the city, urban areas covered with vegetation (public parks, recreation parks, green belts surrounding the housing estates, park-forests, etc.) which are located in the very structure of cities, villages and settlements.

Agricultural production requires irrigation at a rate and time adjusted to the needs of the crop in question. In the maintenance of urban green areas, on the other hand, where the vegetation does not represent a production value, but serves aesthetic purposes and exercises a favourable effect on man, the most efficient production force, irrigation is needed regularly. Besides their aesthetic effects the green surfaces are of sanitary importance. These green surfaces are only able to fulfil their aesthetic and sanitary tasks under adequate biological conditions, i.e. they must be provided with water and nutrients of sufficient quantity and quality.

Green surfaces are established either on intensive, irrigated, or extensive, non-irrigated areas. The intensive green surfaces are established in exposed parts of the city, and the extensive ones on the periphery, in the form of park-forests and protective belts. Among the components of urban green surfaces (trees, shrubs, annual and perennial flowers, grass) it is the grass that occupies the largest area.

On irrigated meadows and pastures where the grass is cut four or five times a year 240—350 mm supplementary water is needed. Grasses which are cut fifteen to twenty times a year, which are planted in most cases on poorer quality soils, but are still expected to remain green from early spring till late in autumn, require several times as much water. On green areas established in exposed parts of the cities irrigation must definitely be carried out throughout the whole vegetation period, otherwise the purpose of conditioning will not be achieved. Aesthetic objections can also be raised against incorrectly irrigated green areas. Yellow, withered vegetation is a miserable sight in summer.

When establishing green surfaces an irrigation system is always constructed on the area. The only trouble is that the irrigation system is supplied with water from the urban drinking-water system, and in periods of water deficiency irrigation is mostly forbidden, in order to be able to supply the population with drinking water.

The solution — a separate irrigation water system — is expensive, but it may be economical in the case of large continuous green surfaces, since the water used for irrigation need not be of drinking-water quality. In the future, when the production cost of "pure water" (drinking-water) will be disproportionately high, it will only be possible to establish green surfaces with separate water systems for irrigation.

UJVÁROSI, M.: Owing to its extremely changeable weather conditions Hungary belongs, in my opinion, to the zone where irrigation is conditional, i.e. the amount of irrigation water required varies from year to year.

There are years when large yields are obtained without irrigation. This occurs when optimum or nearly optimum amounts of water are available for the plants during the growth season. Such ideal conditions throughout the vegetation period seldom occur. In many years the precipitation conditions are favourable in most parts of the growth season, but water deficiency occurs for a longer or shorter period, often on several occasions.

It is also common knowledge that arid years do not occur regularly, and that under the continental, extreme weather conditions of Hungary, particularly on lowland areas, a possibly overabundant water supply in spring or early summer is very often followed by water deficiency in the second half of the growth season, so that crops which cannot develop normally in spring because of an excess of water suffer from drought in summer and can only be helped by irrigation.

Plants are known to have highly varying water requirements in the successive phases of development. If a water deficiency occurs in a period which is critical for yield formation the yield will be considerably reduced even if the shortage of water only lasts for a relatively short time and if optimum amounts of water are available during the rest of the vegetation period. Such critical periods are the intensive growth phase, flowering, yield formation or yield development, and in cereals, for example, the tillering phase, etc.

In Hungary irrigation is mostly aimed at helping the crops through such critical periods and making up for temporary water deficiencies.

This necessitates supplying water in a quantity which varies considerably with the year and the crop and even within the growth season. In many cases regular irrigation would be superfluous or even harmful, and apart from the expense the available water resources would not be sufficient. With a system of regular irrigation a substantially smaller area could be supplied with water in Hungary.

Supplementary irrigation, applied according to need, helps the crops through the critical periods of temporary water deficiency, thus providing the conditions required for steady maximum yields in most years and ensuring an acceptable normal production level even in extremely arid years. Apart from this, the area sown to crops with high water requirements should also be increased to the necessary extent.

VARGA, GY.: For vegetable crops with particu lar requirements with respect to water and soil moisture, irrigation forms an integral part of the agrotechnics in Hungary. Since the amount and distribution of precipitation during the growth season varies, in most years various rates of additional irrigation are required to obtain large yields.

This is confirmed by the results of water balance and irrigation trials carried out over twenty years at the Horticultural Department of the University of Agricultural Sciences, Gödöllő.

In a fifteen-year experiment at Gödöllő the natural water supply was only sufficient to cover the water requirements of cucumbers every three or four years; in other years varying amounts of irrigation water were needed. Every second year it was only with regular irrigation that the maximum yields determined by other conditions could be obtained.

When studying the irrigation of the cucumber variety Hokus, on the basis of soil fertility and by the trend of other factors, primarily temperature, a maximum annual yield of 20—25 ton/ha was obtained (3—15 cm in length). To achieve this result the following amounts of irrigation water were required depending on the precipitation conditions of the different years:

1967	7×30 mm for a yield of 23.2 ton/ha,
1971	6×30 mm for a yield of 25.2 ton/ha,
1968	5×30 mm for a yield of 20.6 ton/ha,
1975	1×40 mm for a yield of 20.3 ton/ha,
1970	no irrigation required for a yield of 23.8 ton/ha.

VARGA, M.: At the Party Congress in 1975, Hungarian agriculture was set task of achieving a 1.5—2-fold increase infproduction over the following 15—20 years. The aim is thus to obtain the largest possible production volume without any deterioration, or if possible with an improvement, in quality. This task presents an extremely complex problem, but the main thing is to create as much harmony as possible between the genetic properties of the crops and the ecological factors. Adaptation to the climatic factors or exercising a favourable influence on them is thus a highly important requirement [LÁNG, I. (1978): Biológiai forradalom — hazai realitások (Biological revolution — Hungarian realities). Akadémiai Kiadó, Budapest].

Since water is the most important of the ecological conditions in Hungary, in practice it is the limiting factor for a further increase in production. It is therefore necessary to ensure the optimum water supply to the crops by irrigation. However, a categorical answer cannot be given to the question of whether Hungary belongs to the zone of conditional irrigation, where different amounts of irrigation water have to be supplied each year to attain large yields, or whether irrigation should become an integral part of the agrotechnics. In my opinion irrigation should form an integral part of the agrotechnics; knowing the geographic and climatic conditions of Hungary and their regional and seasonal differences, however, the rate of irrigation on different agricultural areas and for different crops should obviously be adjusted to the actual situation.

According to Láng (ibid.) even if irrigation farming is developed the irrigated agricultural area of Hungary is not likely to be more than 14—15% by the turn of the century (it is at present 6.3—6.7% of the agricultural area), i.e. the majority of crops will still have to be produced without irrigation. Therefore the improvement of the water regime of the crops by genetic, agrotechnical and other means will remain a task of primary importance.

As a plant physiologist engaged in research I think that one of the basic preconditions for obtaining larger yields either with or without irrigation is to acquire a thorough knowledge of the water regime of the plants by carrying out basic research at a high level and applying the results in practice as soon as possible.

On reviewing the subjects of biological research in Hungary basic investigations into the water balance and water utilization of plants, or on the relationship between the water regimes of the plant and the soil are hardly found. Even the few which do exist are carried out in isolation; there is in fact no history of this field of plant physiology in Hungary. It is extremely regrettable that in a period when biological research is making rapid progress in Hungary the number of studies on the water regime of plants is not at all in proportion with its national economic importance, and that this subject has not been given national priority with co-ordination at a high level. Yet there can be no doubt that if the task facing agriculture is to be achieved, i.e. if yield averages are to be nearly doubled by the end of the century, basic research of this type is badly needed even today, and will be still more necessary in the coming decades. This work will mainly fall to the biophysicists, I imagine, as the up-to-date examination of the questions of water balance and water economy in plants which are so far unelucidated goes beyond the scope of plant physiology, and, although it is difficult to draw the line, is gradually becoming partly, if not totally, the field of biophysics.

However, the biological research institutions seem to be gradually becoming aware of the great importance of the subject, so steps to make up for the backlog may be expected in the near future. It should be added, though, that the fact that the fast rate at which plant physiological and biophysical research has developed due to the biological revolution has hardly affected the subject of water regime in plants compared to other fields of research is not only a Hungarian but also a world wide phenomenon.

On the other hand, the research results already available should be applied in agricultural practice to a greater extent. The possibilities offered by the physiology of water balance should and could be better used in the service of irrigation in large-scale crop production farms. Numerous practical opportunities exist, with methods elaborated for laboratory and field conditions alike. For the plant, for example: application of the morphological, biological and biochemical indices of drought tolerance; determination of the actual water balance and the critical saturation deficiency; determination of the intensity of transpiration and the trend of the T/E ratio, etc. With respect to the soil, on the other hand, it would be particularly important to determine the constant withering % (the withering point) throughout the vegetation period, since this is the most important limit value in the relationship between the water content of the soil and the plant. The regular recording of these numerical data for various plant stands would provide a good basis for the determination of rates and dates of irrigation. For this purpose efforts should be made to construct ingenious measuring instruments which would be easy to transport and could thus be used in the field.

But in the narrower field of growth physiology, results which can be utilized in influencing the water metabolism of the plants can also be attained. Mention should be made, for instance, of the possibility of increasing the drought tolerance of certain plants by using growth retardants. According to the results of experiments with wheat, barley, bean, sunflower, etc. plants treated with CCC, Phosfon-D and B-9 (Alar) show a higher tolerance to water deficiency, and less damage and more rapid rehydration after long dry periods. With germination and growth stimulants, e.g. with gibberellic acid, the vegetation period can be substantially shortened for numerous plants, and thereby drought induced damage can mostly be avoided [Weaver, R. J. (1972): Plant growth substances in agriculture. W. H. Freeman and Co., San Francisco; Varga, M. (1976): Növekedésszabályozó anyagok gyakorlati alkalmazása a növénytermesztésben (The use of growth substances in plant production). JATE egyetemi jegyzet, Szeged; Varga, M.—Stumpf, I. (1979): Hastening the germination of crop seeds and increasing the seedling growth with gibberellic acid. Acta Biol. Szeged, **24** (in press)]. These and other similar methods would be worth testing widely under Hungarian conditions.

The increased application in practice of research results concerning the water metabolism of plants and the wide introduction of the available methods requires the close co-operation of agriculturists and biologists. If the possibilities are to be exploited adequate financial conditions and a freer exchange of researchers are also required.

Váncsa, J.: In deciding whether or not the area under agricultural cultivation in Hungary belongs to the zone of conditional irrigation, the following should be taken into consideration:

According to the results of scientific investigations and surveys the annual amount of precipitation in an average hydrometeorological year in Hungary can be taken as 58 km³. Of this, 38—40 km³ falls on agricultural areas. The loss due to run-off, deep infiltration, evaporation outside the growth season, etc. is about 17 km³. The amount of useful precipitation is thus 22 km³, which corresponds to an average of 320 mm. At the present economic level 90% of this is utilized in the process of evapotranspiration.

In 30% of those years when the weather conditions deviate from the average, the amount of precipitation is considerably more than this, while in 30% it is substantially less. There are also considerable differences between regions in this respect. Of the 320 mm useful precipitation which represents the national average, only 260—280 mm falls on the Great Plain.

The average values naturally conceal the fact that the amount of useful precipitation may be considerably greater in soils with high water capacity and retention, and less in other places.

It follows that if the water requirements of the genetic bases used are taken into consideration efficient drop production can be carried out even under dry farming conditions in Hungary. Farming results, i.e. profitability, is, however, dependent on the soil . the topography and the regional location, so it fluctuates from year to year but is, in the long run, predetermined. The role of these factors varies depending on what plants are grown, and on how their water requirements develop. From this and from the available water supplies it follows that in the case of plants with high water requirements large yields can only be obtained when irrigation becomes an integral part of the agrotechnics, while for crops with a medium water requirements, annually varying quantities of irrigation water must be supplied, depending on the amount of natural precipitation.

VÁRALLYAY, GY.: The final aim of agriculture and forestry is the production of good-quality, maximum-quantity yields to satisfy the ever-growing demands of the population, without the production having any harmful side-effects, e.g. without any unfavourable human-induced changes in the natural environment, in the well-balanced equilibrium state of the biosphere.

The primary task of agricultural water management is to artificially regulate the soil moisture regime in such a way as to create an optimum soil ecological environment (guaranteeing the continuous and economically rational supply of natural vegetation and cultivated crops with water, air and mineral nutrients), to influence favourably the mass and energy regimes of the soil, to increase potential and actual soil fertility and to ensure favourable soil technology conditions for the various agrotechnical operations, and for the development of up-to-date, fully-mechanized production systems [SZABOLCS, I.—VÁRALLYAY, GY. (1978b): A talaj termőképességének megóvása és fokozása belvízgazdálkodással (Maintenance and enhancement of soil fertility by means of water management). Magyar Hidrológiai Társaság, VI. Vándorgyűlés anyaga, Debrecen; VÁRALLYAY, GY. (1978): A talajfizika helyzete és jövőbeni feladatai (Present state and future tasks of soil physics). Agrokémia és Talajtan, **27**, 203—218].

The necessity for agricultural water management and the conditions under which the various measures are carried out are determined not only by the climatic conditions and the requirements of the cultivated crops, but also by the hydrophysical properties and the moisture regime, i.e. the water management of the soil. The main factors of this are the depth, thickness and sequence of the various horizons within the soil profile between the soil surface and the groundwater table, as well as their hydrophysical characteristics: the quantity, status, chemical composition (concentration and ion composition), and vertical and horizontal movement of the soil moisture. For an exact and accurate characterization of the soil water management quantitative information is necessary on the above-mentioned parameters, as well as on their spatial distribution and dynamism in time, and on the mechanisms and conditions of factors influencing this.

In the most recent period of Hungarian agricultural development a considerable increase in the yields of the main agricultural crops could be obtained with little more than a high rate of increase in the use of mineral fertilizers, because in most Hungarian soils the less than adequate macro-nutrient supply was the limiting factor of fertility. But this trend cannot be expected to continue in the future. High-quality crop yields cannot be achieved simply by mechanically increasing the fertilizer level (quantity of mineral fertilizers used per unit area), because other factors (micro-nutrient supply, water supply, physical and hydrophysical soil characteristics, technological properties determining and sometimes limiting the possibilities of mechanized agrotechnics, etc.) become the limiting factors for high yields. Consequently, plans for an intensive further increase in crop yields can only be fulfilled if, besides the rationally optimum satisfaction of the nutrient requirements of the crops, the unfavourable influences of these other limiting factors are eliminated or at least moderated.

For this purpose a comprehensive synthesis is necessary, including the description, characterization, evaluation and mapping of all the limiting factors of soil fertility. Using this approach Szabolcs and Várallyay prepared a map, based on a large number of data and maps, showing the limiting factors of soil fertility in Hungary, on the scale of 1 : 500,000 [SZABOLCS, I.—VÁRALLYAY, GY. (1978a): A talajok termékenységét gátló tényezők Magyarországon (Factors inhibiting soil fertility in Hungary). Agrokémia és Talajtan, **27**, 181—202]. On the map the following categories, the main limiting factors of soil fertility, were distinguished: 1. Extremely light texture; 2. Acidity; 3. Salinity-alkalinity; 4. Salinity-alkalinity in the deeper soil layers; 5. Extremely heavy texture; 6. Water-logging (peat formation); 7. Erosion; 8. Solid rock near to the surface.

A simplified outline of the map is presented in Fig. 1. The acreage of lands where soil fertility is limited by one or more of the above-mentioned factors is summarized in Table 1.

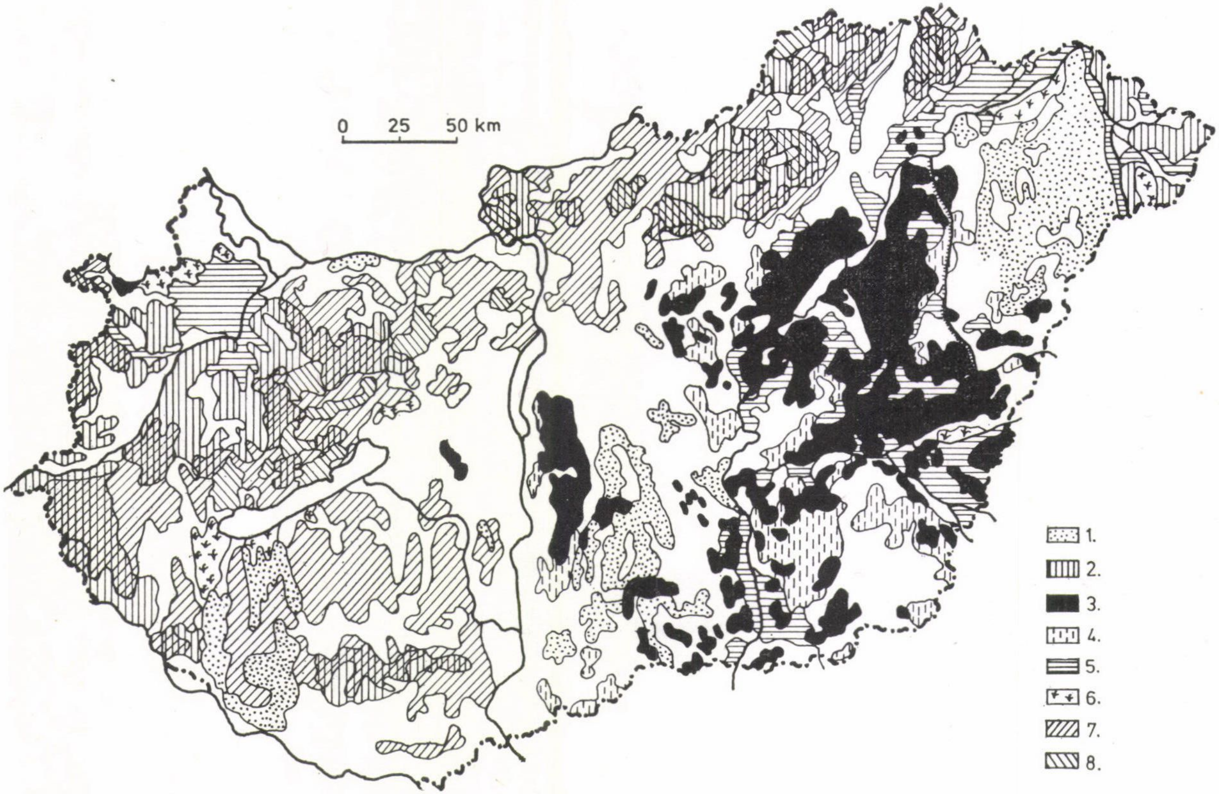


Fig. 1. Map of the limiting factors of soil fertility in Hungary. Original scale: 1 : 500,000 (Main limiting factors of soil fertility: 1. Too coarse texture; 2. Acidity; 3. Salinity and/or alkalinity; 4. Salinity and/or alkalinity in the deeper horizons; 5. Too heavy texture; 6. Water-logging; 7. Erosion; 8. Solid rock near the surface)

Table 1

Limiting factors of soil fertility in Hungary
(based on the 1 : 500,000 scale map)

Limiting factor of soil fertility	Area in 1000 hectares		Area as a percentage of the total area used by agriculture and forestry		Area as a percentage of the total area	
1. Extremely coarse texture	746		8.9		8.0	
2. Acidity						
(a) combined with erosion		348		4.2		3.7
(b) combined with solid rock near the surface		67		0.8		0.7
3. Salinity and/or alkalinity	757		9.0		8.1	
4. Salinity and/or alkalinity in the deeper horizons	245		2.9		2.6	
5. Extremely heavy texture	630		7.5		6.8	
6. Water-logging	161		1.9		1.7	
7. Erosion	1455		17.4		15.6	
(c) combined with acidity		348		4.2		3.7
8. Solid rock near to the surface	217		2.6		2.3	
(c) combined with acidity		67		0.8		0.7
(d) Total	4996*		59.5*		53.5*	

* In the case of soil acidity combined with erosion or with solid rock near the surface, only one factor was taken into account.

Most of the categories are directly or indirectly related to soil water management. Some of the factors are the results and consequences of a typical moisture regime. For instance the primary reasons for peat formation are permanent or temporary water-logging, permanent over-saturation with water, extremely high moisture content, and the physical, chemical, biological and mass-regime consequences of these factors (natural vegetation with high biomass production; dominantly anaerobic conditions → → slow decomposition of plant residues → high organic matter content). Water, as a reactant, solvent and transporting agent, plays an important, and sometimes decisive, role in the salinization and/or alkalization processes; consequently the soil water management has particular significance in the formation and development of salt-affected soils. The majority of soil erosion damage is also closely related to soil water management (limited infiltration → surface run-off → lateral erosion).

At the same time, most of the limiting factors (e.g. extremely light or extremely heavy texture, salinity-alkalinity, solid rock near to the surface, etc.) hinder directly (limitation of the adequate water supply to the plants; limitation of the time interval when the technological properties and moisture status of the soils are favourable for the high-quality execution of the various agrotechnical measures, etc.) or indirectly (by influencing the air and heat regime, the biological activity and the nutrient regime of the soil, etc.) the fertility of the soil, the production of high crop yields and the harvesting of these crops with minimum losses, through their unfavourable effect on the soil water management [VÁRALLYAY, GY. (1978): A talajfizika helyzete és jövőbeni feladatai (Present state and future tasks of soil physics). Agrokémia és Talajtan, **27**, 203—218].

The main limiting factors of the adequate water supply to the plants are schematically summarized in Figs. 2 3 and 4 [VÁRALLYAY, GY. (1977): Soil water problems related to salinity and alkalinity in irrigated lands. In: WORTHINGTON, E. B.: Arid land irrigation in developing countries. Environmental problems and effects.

Trans. Int. Symp. Alexandria. Pergamon Press, Oxford, 251—264; VÁRALLYAY, GY. (1979): Soil factors limiting optimum water-supply of plants. Proc. Int. Scientific Symposium "The influence of physical factors of soil environment on plant production", Lublin].

As can be seen in Fig. 2, in coarse-textured soils (coarse sands, humous sands, etc.), the limited water storage capacity (FC) is mainly due to limited water retention, a too high infiltration rate (IR) and hydraulic conductivity (HC). This is the main reason for the low fertility and extreme drought sensitivity of these soils.

All over the world there are extensive areas covered by a surface crust which is cemented by salts, gypsum, $CaCO_3$, etc. or compacted by misguided soil management: over-tillage, heavy machinery, incorrect irrigation practice, etc. In other cases

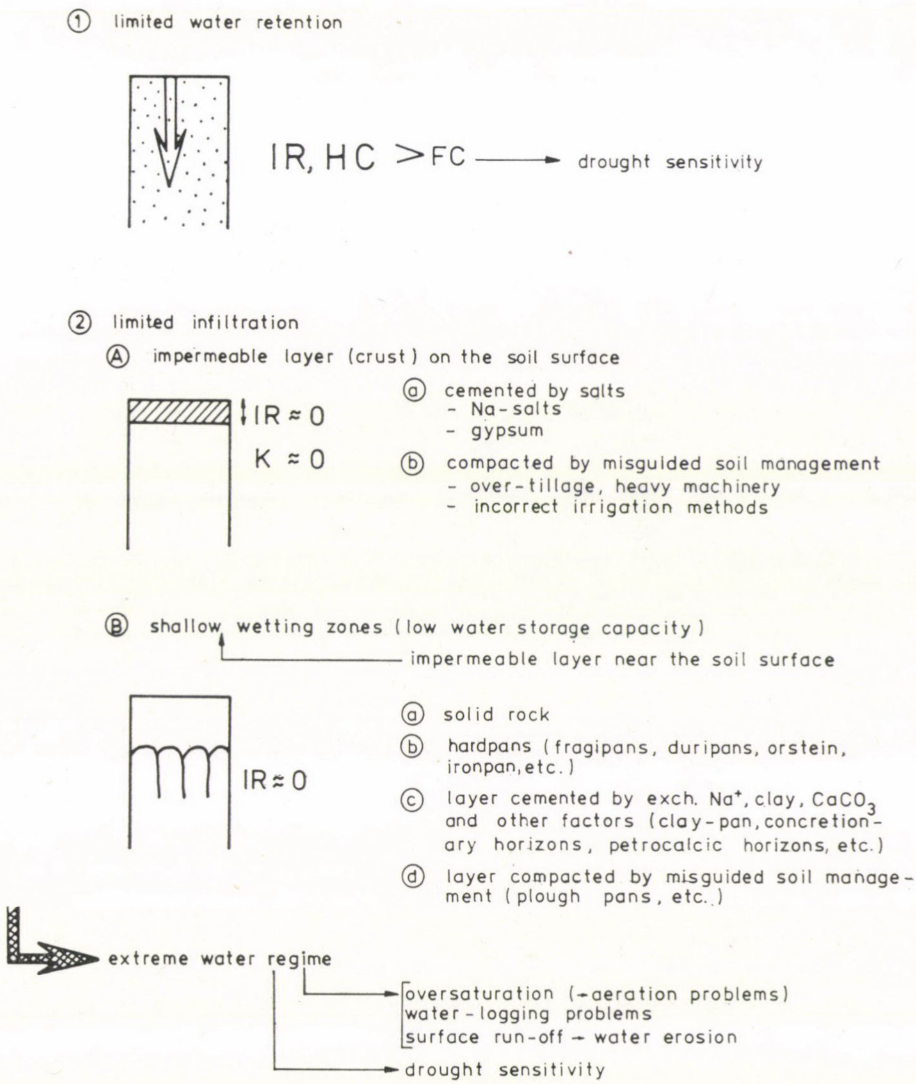


Fig. 2. Soil factors limiting optimum water supply of plants. I. Limited water storage capacity

an impermeable (or nearly impermeable) layer occurs within the soil profile near to the surface. This may be solid (or moderately fragmented) rock, various hardpans (fragipans, duripans, orstein, ironpan, etc.), horizons cemented and compacted by accumulation of inorganic colloids (clay, sesquioxides, etc.), $CaCO_3$ or exchangeable Na^+ (illuvial, concretionary, petrocalcic, or solonetz B-horizons, clay-pans, etc.) or layers compacted by incorrect agrotechnics (plough-pans, etc.). In these cases, not only is root penetration retarded, but the infiltration of water to the soil is also limited and creates an extreme moisture regime. The very low infiltration rate results in oversaturation and aeration problems (decreasing the availability of plant nutrients, anaerobic biological

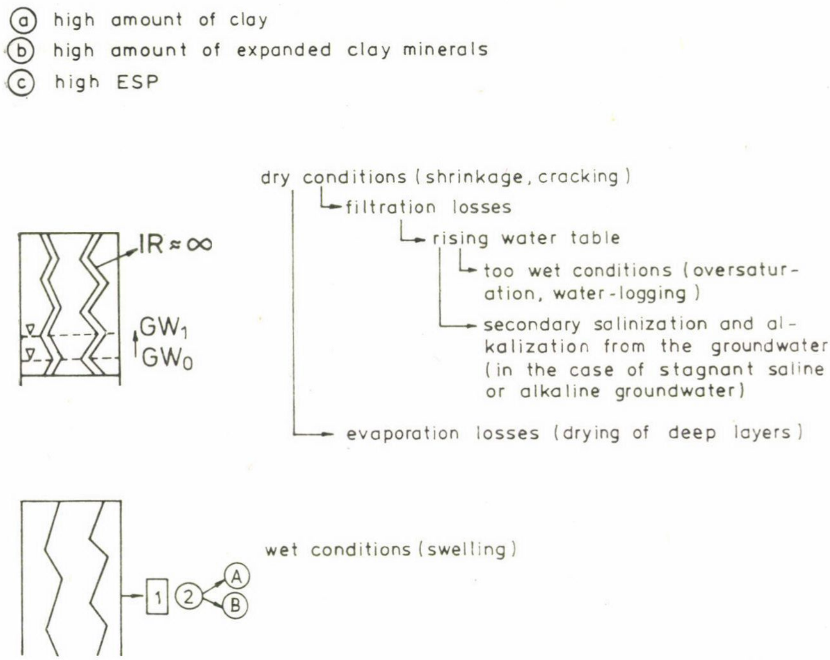


Fig. 3. Soil factors limiting optimum water supply of plants. II. Cracking (swelling-shrinkage phenomena)

processes, unfavourable reduction, etc.) in the shallow wetting zone, in temporary water-logging after rainfall or irrigation, and in considerable evaporation losses and surface run-off (→ lateral erosion). The water storage capacity of this shallow wetting zone is very low, so it can only satisfy the water consumption of the plants for a short period. This is the main reason for the special drought sensitivity of these soils even under irrigated conditions.

Crack formation in swelling clays causes another water problem in heavy-textured soils. The main reasons and consequences of these phenomena are schematically illustrated in Fig. 3. When the soil is dry, some of the rain or irrigation water flows through the open cracks directly to the groundwater. These "filtration losses" diminish the water storage of the soil, decrease water use efficiency and, at the same time, may result in a rise in the water table, which may be accompanied by such unfavourable processes as water-logging, oversaturation of the deeper layers (in the case of a high water table) or secondary salinization and alkalization (in the case of shallow, stagnant, saline groundwater) [Darab, K. (1962): Talajgenetikai elvek alkalmazása az Alföld öntözésénél (The use of soil genetic principles in irrigation on the Great Plain). OMMI, Budapest; Darab, K.—Ferencz, K. (1969): Öntözött területek talajtérképezése (Soil mapping of irrigated areas). OMMI, Budapest; Anonymous (1967): International

source book on irrigation and drainage of arid lands in relation to salinity and alkalinity. FAO/UNESCO, Paris; ANONYMOUS (1976): Prognosis of salinity and alkalinity. Report of an expert consultation, Rome, 1975. FAO Soils Bulletin No. 31, Rome; KOVDA, V. A.—SZABOLCS, I. (Eds.) (1979): Modelling of soil salinization and alkalization praesses. Agrokémia és Talajtan, **28**, Suppl.; SZABOLCS, I. (1961): A vízrendezések és öntözések hatása a tiszántúli talajképződési folyamatokra (The effect of water regulation and irrigation on soil formation processes in the Trans-Tisza Region). Akadémiai Kiadó, Budapest; SZABOLCS, I. (1979): Review of research on salt-affected soils. UNESCO, Paris; SZABOLCS, I.—DARAB, K.—VÁRALLYAY, GY. (1969): Methods of predicting salinization and alkalinization process due to irrigation on the Hungarian Plain. Agrokémia és Talajtan, **18**, Suppl. 351—376; VÁRALLYAY, GY. (1977): Soil water problems related to salinity and alkalinity in irrigated lands. In: WORTHINGTON, E. B.

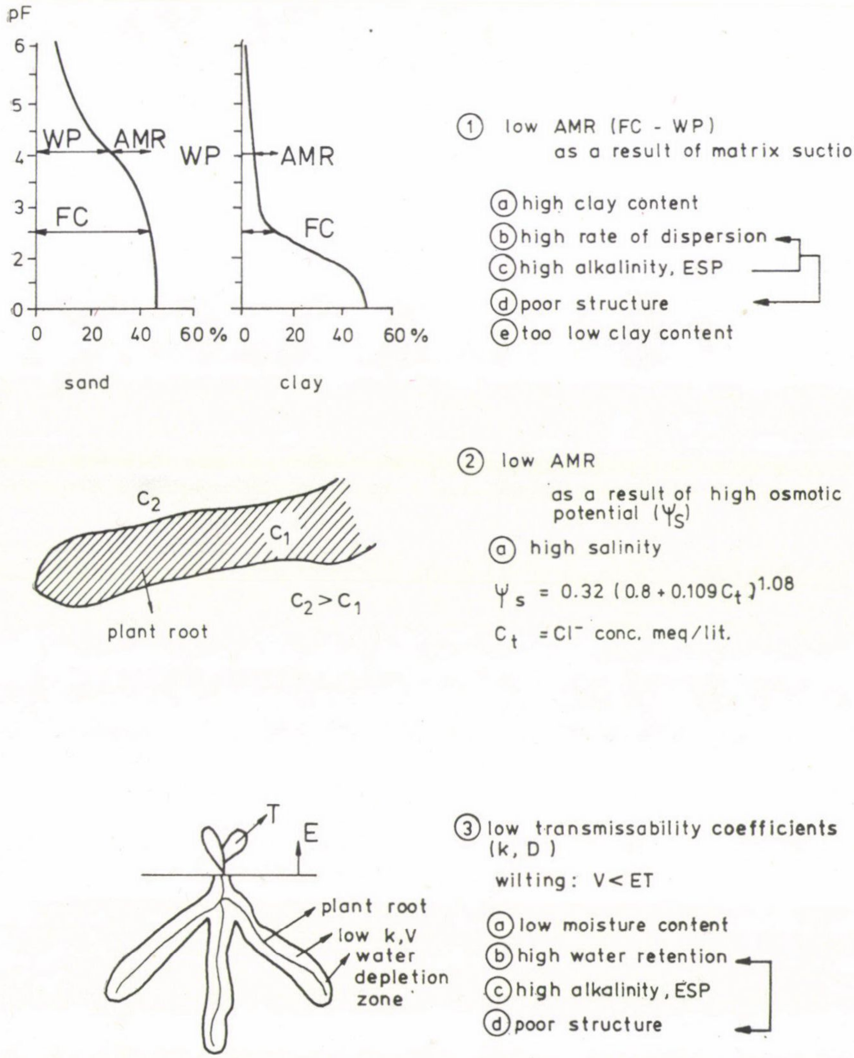


Fig. 4. Soil factors limiting optimum water supply of plants. III. Low availability of soil moisture

Arid land irrigation in developing countries. Environmental problems and effects. Trans. Int. Alexandria. Pergamon Press, Oxford, 251—264; WORTHINGTON, E. B. (1976): Arid land irrigation in developing countries. Environmental problems and effects. Trans. Int. Symp. Alexandria. Pergamon Press, Oxford]. During dry periods the soil may dry out deeply through the deep, wide cracks (→ considerable evaporation losses). In rainy seasons the clogging cracks impede the uniform wetting of the soil and result in problems similar to those mentioned previously (Fig. 2).

A further group of soil factors limiting the optimum water supply to the plants can be summarized as "low availability" of soil moisture (Fig. 4). This is the direct or indirect consequence of various phenomena:

— narrow available moisture range (AMR) in coarse-textured soils because of their very low water retention (low field capacity, FC);
— narrow AMR in heavy-textured (sometimes Na^+-saturated) swelling clays because of their very high water retention (high wilting percentage, WP);
— high osmotic potential (Ψ_s) due to the high concentration of the soil solution (in comparison to the electrolyte concentration in the plant root tissues) [ANONYMOUS (1967): International source book on irrigation and drainage of arid lands in relation to salinity and alkalinity. FAO/UNESCO, Paris];
— extremely low transport coefficients (capillary conductivity, k and difusivity, D); in spite of the high suction gradient the flux from the wet soil to the plant roots is extremely slow through the thin but relatively dry "film-like" moisture depletion zone formed around the plant roots. As a consequence of this peculiar microdistribution pattern of soil moisture, the plants (especially of crops with scarce, widely-spaced root systems) show water deficiency symptoms even if the soil bulk has a considerable moisture content.

These factors are schematically illustrated in Fig. 4 [KOVDA, V. A.—SZABOLCS, I. (Eds) (1979): Modelling of soil salinization and alkalization processes. Agrokémia és Talajtan, **28**, Suppl.; VÁRALLYAY, GY. (1977): Soil water problems related to salinity and alkalinity in irrigated lands. In: WORTHINGTON, E. B.: Arid land irrigation in developing countries. Environmental problems and effects. Trans. Int. Symp. Alexandria. Pergamon Press, Oxford, 251—264; VÁRALLYAY, GY. (1978): A talajfizika helyzete és jövőbeni feladatai (Present state and future tasks of soil physics). Agrokémia és Talajtan, **27**, 203—218].

This is a world-wide problem and it is no exaggeration to state that the life of the rapidly increasing world population and the possibility of satisfying the food and fibre demands of this population, which are continually increasing both qualitatively and quantitatively, depend to a great extent on the rational use of limited water resources [WORTHINGTON, E. B. (1976): Arid land irrigation in developing countries. Environmental problems and effects. Trans. Int. Symp. Alexandria. Pergamon Press, Oxford]. The water requirements of both extensive (territorial extension of agricultural areas and arable lands in arid and semi-arid regions) and intensive (satisfaction of the increasing ecological requirements of highly productive, intensive varieties; an approach to the optimum water and nutrient supply of crops; a guarantee of the maximum effect of a high rate of fertilizers; the creation of an optimum soil physical environment for the various agrotechnical measures; an increase in the dependability of high yields) agricultural development are growing sharply. At the same time the water resources available for agriculture are decreasing, because of the increasing water demand of industry, urbanization, recreation, etc. This is quite obvious if the fundamental principles of water resource management and of environmental protection are taken into consideration. On the other hand, the use of water for various purposes often results in unfavourable changes in water quality, which means a further decrease in the quantity of good-quality water resources available for agriculture. The elimination of the contradiction between the increasing demand and the decreasing available water resources is only possible by the exploitation of new water resources and/or by an increase in water use efficiency. The former is often limited by water quality problems (e.g. the use of relatively highly salinized groundwaters for irrigation, etc.), and the desalination of sea-water is so expensive and energy-consuming, that this possibility can only be taken into account in special cases even for the drinking-water supply; it cannot be realistically counted on for the "production" of irrigation water even in the distant future. Consequently, the key-problem of the agricultural water supply is the improvement of water use efficiency. Since in most cases (even in countries with rich, long-term agriculture and irrigation traditions and high-level agricultural and irrigation development) this efficiency is very low, there is enormous potential for a high degree of improvement in this field. This is valid even for the moderately humid climate of the Hungarian Plain, where under the given climatic conditions (uneven time and territorial distribution of atmospheric precipitation, especially during the vegetation period) and at the present level of agriculture, the soil water management and its artificial regulation, the elimination of extreme soil moisture conditions (extremely wet conditions result in sticky soil consistency, increasing the hazard of floods and water-logging, surface run-off and water erosion; extremely dry conditions are related to higher drought probability, agrotechnical difficulties, etc.) and the rational and efficient use of atmospheric precipitation and irrigation water are extremely important, much more so than previously.

Theoretically there are two main tasks facing agricultural water management in Hungary:

— the drainage of excess waters, and

— supplementary irrigation.

These two main tasks appear differently at various times and places. Theoretically, and even more so practically, there are various potential possibilities for their successful solution. The best variants, which must be properly planned and executed, should be selected, taking into consideration the natural conditions and certain other factors, such as the technical conditions, the standard of farming, economic factors, efficiency, etc.

In Hungary, and especially on the Hungarian Plain, the fundamental basis of agricultural water management is the maximum use of atmospheric precipitation [Fekete, I. (1971): A mezőgazdasági és öntözésfejlesztés összefüggései (Relationships between agricultural and irrigation development). D. Sc. Thesis, Budapest; Szabolcs, I.—Várallyay, Gy. (1978b): A talaj termőképességének megóvása és fokozása belvízgazdálkodással (Maintenance and enhancement of soil fertility by means of water management). Magyar Hidrológiai Társaság, VI. Vándorgyűlés anyaga, Debrecen; Várallyay, Gy. (1978): A talajfizika helyzete és jövőbeni feladatai (Present state and future tasks of soil physics). Agrokémia és Talajtan, **27**, 203—218]. In Hungary the 550 mm/year average precipitation would theoretically cover the water requirements of the cultivated crops (or at least most of them) even at a considerably higher yield level. But the uneven time and territorial distribution of the rainfall is typical in this region and only a relatively small part of the precipitation water reaches the plants, and is taken up and used effectively by agricultural crops. This is why, in spite of the generally favourable climatic conditions of the Hungarian Plain, problems connected with the continuous, adequate water supply to the plants arise relatively often and necessitate supplementary irrigation.

Since there are objective limitations to the extension of irrigation on the Hungarian Plain (limited water resources, uneven topography, water quality problems, salinity-alkalinity hazards, etc.), the irrigation lands cannot exceed 20% of the total agricultural area even in the distant future. Consequently, a high-level agricultural water management system must be established which will guarantee a reliable, adequate water supply to the crops at the future high level of agricultural production (intensive varieties, high rate of fertilizers, etc.).

Under such conditions the main objective cannot be other than to improve the water use efficiency, which is usually closely related to soil conditions. Primarily, it is the properties and the state of the soil which determines the quantity of water, derived from the atmosphere or applied during irrigation, which runs off and/or directly evaporates from the soil surface, filtrates through the soil profile and feeds the groundwater, and which is stored within the soil pores. Besides the biological properties of the cultivated crops and the characteristics of the plant stands, the soil conditions also determine what portion of the water stored in the soil is available to the plants and can be successfully used for phytomass production.

It is quite obvious from the above that for the realization of the various tasks of agricultural water management detailed information is necessary on the soil conditions, on the various soil properties, and, in particular, on the physical and hydrophysical characteristics of soils which primarily determine their moisture regime and water management. On this basis the most important tasks of agricultural water management can be determined and the effect they can be expected to have on the soil properties can be forecasted. On the basis of these analyses the most effective and economic variants can be selected from the theoretical possibilities, and appropriate technologies can be elaborated for these variants [Várallyay, Gy. (1976b): Talajtani irányelvek vízrendezési tervek elkészítéséhez (Guiding principles in soil science for the preparation of water regulation plans). Manuscript, Budapest; VÁRALLYAY, GY. (1978): A talajfizika helyzete és jövőbeni feladatai (Present state and future tasks of soil physics). Agrokémia és Talajtan, **27**, 203—218; VÁRALLYAY, GY.—SZÜCS, L.—MÉLYVÖLGYI, J. (1975): Békés megye talajviszonyai, különös tekintettel a terület mezőgazdasági vízgazdálkodására (Soil conditions in Békés county, with special reference to the agricultural water management of the area). Manuscript, Budapest].

The detailed analyses and evaluation of the various soil properties gives an exact scientific information basis for the judgement of the necessity of irrigation (especially that of supplementary irrigation) and for the determination of its conditions (date, timing, frequency and maximum intensity of irrigation; quantity of irrigation water which can or should be applied; irrigation method(s); the necessity and possibilities for draining excess waters, etc.).

factors of agricultural water management	moisture content as volume percentage, %	wilting point (pF 4.2) WP	available moisture range, AMR	field capacity, FC	saturated hydraulic conductivity, K	unsaturated hydraulic conductivity, K	infiltration rate, IR	depth of the wetting zone, d	chemical composition of the soil solution	
necessity of irrigation	●	●	●							
date of irrigation	●	●	●							
quantity of irrigation water which can be applied	●			●				●		type and method of irrigation
quantity of irrigation water which must be applied	●	●	●	●				●		
frequency of irrigation			●	●						
intensity of irrigation					●	●	●			
quality of irrigation water which can be applied				●	●	●			●	
necessity of surface drainage	●			●		●	●			
necessity of subsurface drainage	●			●	●	●		●		

Fig. 5. Soil factors which have to be taken into consideration in the planning and development of agricultural water management

In Fig. 5 the various soil properties, and physical and hydrophysical parameters which have to be taken into consideration for the determination and planning of agricultural water management, particularly of the conditions of irrigation, are schematically summarized. To give just a few examples in this connection: From the viewpoint of soil conditions irrigation is necessary if the actual moisture content of the soil decreases to the wilting point (WP), because in such cases there is no available water for the plants within the soil. The maximum quantity of water which can be applied during one irrigation is limited by the water-free pore volume. The amount of water which can rationally be used per irrigation is also determined by the water storage capacity of the soil (FC) and the available moisture range (AMR). The duration of the period in which the water stored in the soil ensures a continuously adequate water supply to the plants depends primarily on the AMR, so this determines the rational frequency of irrigation. On the basis of this information, with the addition of parameters determining the maximum intensity (mm/hour) of irrigation, such as infiltration rate (R), saturated (K) and unsaturated (k) hydraulic conductivity, conclusions can be drawn concerning the best method of irrigation. The quality requirements for the irrigation water depend not only on the salt-tolerance of the crops, but also on the drainage conditions (internal drainage within the soil profile, drainage characteristics of the given area) and on the chemical composition (concentration, ion-composition) of the soil solution [Darab, K. (1962): Talajgenetikai elvek alkalmazása az Alföld öntözésénél (The use of soil genetic princ ples in irrigation of the Great Plain). OMMI, Budapest; Darab, K.—Ferencz, K. (1969): Öntözött területek talajtérképezése (Soil mapping of irrigated areas). OMMI, Budapest; Ferencz, K. (1973): A talajok vízgazdálkodási sajátságai a Középtiszavidéken, különös tekintettel az öntözésre (Special features of soil water management in the Mid-Tisza Region, with particular reference to irrigation). C. Sc. Thesis, Budapest; Szabolcs, I. (1961): A vízrendezések és öntözések hatása a tiszántúli talajképződési folyamatokra (The effect of water regulation and irrigation on soil formation processes in the Trans-Tisza Region). Akadémiai Kiadó, Budapest; Szabolcs, I. (1976): A talaj tulajdonságai és az öntözés (Soil characters and irrigation). Agrártudományi Közlemények, **35,** 149—157; Várallyay, Gy. (1976a): Az öntözés néhány talajfizikai vonatkozása (Some soil physical aspects of irrigation). MTA Agrártudományi Osztály Közleményei, **35,** 159—165].

There is a sharply increasing qualitative and quantitative demand for well-defined, exact, quantitative hydrophysical parameters which are easily and accurately measurable or calculable. Hungarian soil science and routine soil and agrochemical surveys (including field surveys, laboratory analyses, data processing and interpretation) is able to satisfy these requirements to an ever increasing extent [Várallyay, Gy. (1972): A Magyar Alföld szikes talajainak hidraulikus vezetőképessége (The hydraulic conductivity of alkali soils on the Hungarian Plain). Agrokémia és Talajtan, **21,** 57—88; Várallyay, Gy. (1973a): A talaj nedvességpotenciálja és új berendezés annak meghatározására az alacsony (atmoszféra alatti) tenziótartományban (The moisture potential of the soil and new equipment for measuring it in the low /less than atmospheric/ tension range). Agrokémia és Talajtan, **22,** 1—22; Várallyay, Gy. (1973b): Berendezés bolygatatlan szerkezetű talajoszlopok hidraulikus vezetőképességének meghatározására (Equipment for determining the hydraulic conductivity of soil columns with undisturbed structure). Agrokémia és Talajtan, **22,** 23—38; Várallyay, Gy. (1974a): Hydrophysical aspects of salinization processes from the groundwater. Agrokémia és Talajtan, **23,** Suppl., 29—44; Várallyay, Gy. (1974b): Háromfázisú talajrétegekben végbemenő vízmozgás tanulmányozása (Study of water movement in three-phase soil horizons). Agrokémia és Talajtan, **23,** 261—296; Várallyay, Gy.—Rajkai, K.—Pachepsky, Ya. A.—Mironenko, E. V. (1979a): A pF-görbék matematikai leírása (Mathematical description of pF-curves). Agrokémia és Talajtan, **28.**]

At the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences a new soil map of Hungary was completed in 1978 by Várallyay and Szücs, on the scale of 1 : 100,000 [Várallyay, Gy.—Szücs, L. (1978): Magyarország új, 1 : 100 000 méretarányú talajtérképe és felhasználási lehetőségei (New, 1 : 100,000 scale soil map of Hungary and ways of using it). Agrokémia és Talajtan, **27,** 267—288]. In 1979, on the basis of this map and of further information, a thematical soil map was prepared on the same scale (1 : 100,000) by the Soil Science Department of the above-mentioned Institute. On the map the following soil properties were indicated with the application of a coded classification system suitable for computerized data storage and data processing [Várallyay, Gy.—Szücs, L.—Zilahy, P.—Rajkai, K.—Murányi, A. (1979b): 1 : 100 000 méretarányú térkép a talaj termékenységét befolyásoló tényezőkről (1 : 100,000 scale map of the factors influencing soil fertility). Agrokémia és Talajtan, **28**, 363–384]:

(1) Soil type and subtype (classified into 31 units),
(2) Parent material (9 categories),
(3) Soil reaction and carbonate status (5 categories),
(4) Textural classes (7 categories),
(5) Water management properties of soils (9 categories),
(6) Organic matter resource in soils (6 categories),
(7) Depth of soil profile (5 categories).

Parallel with this work a new, modified system was elaborated for the categorization of soils according to their water management. This system is based on the profile characteristics (depth, thickness and sequence of the various diagnostic horizons) and the measured, computed or estimated values for the various hydrophysical parameters (field capacity, FC; wilting percentage, WP; available moisture range, AMR; infiltration rate, IR; saturated hydraulic conductivity, K), characteristic of the different horizons (layers). Investigations are being carried out by Várallyay and Rajkai, aimed at giving a more exact definition and characterization of these categories and at increasing their information content, by using measured or computed values of further hydrophysical parameters (mathematically described water retention curves; saturated conductivity as a function of time, K(t); unsaturated conductivity as a function of suction or moisture content, $k(\Psi)$, $k(\Theta)$].

On the basis of these categories a comprehensive system of survey, analysis, categorization, mapping, monitoring and prognosis will be elaborated for the precise characterization of soil water management. A soil information system of this type is an indispensable basis for the development of an optimum (or a rational approach to optimum) agricultural water management. On the basis of this information conclusions can be drawn on irrigation problems as well. For instance, when and where irrigation is necessary, rational, successful, efficient and economic under the given natural environment and in the given economic situation; what the preconditions of such irrigation are; what the potential favourable changes and unfavourable side-effects of irrigation are, etc.

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PÁL, GY.: **At the end of the 1940s 70% of the irrigation area in Hungary was found in the Great Plain, a region with low fertility soils, poorly supplied with precipitation. This was mainly due to the rice production. On better quality soils irrigation, on a farm scale, was more efgicient, since the index of economic efficiency for irrigation increases or decreases parallel to the fertility of the soil. Do you think irrigation should first be developed on a national scale on poor or on good quality soils?**

ALMÁSI, T.: It is an indisputable fact that in the past three or four decades the development of irrigation has been concentrated on the Great Hungarian Plain, a region with poor precipitation, unfavourable relief conditions, and worse than average fertility and soil structure. (With the exception of a few vegetable growing districts irrigation traditionally meant the irrigation of pastures, plus the flooding of rice fields during the last four decades.)

However, the objective conditions of the Carpathian basin must not be left out of consideration; the deficiencies in energy and capital during the last three decades did not leave much opportunity for conveying irrigation water to great distances in order to supply water to areas with favourable natural conditions. The construction and action radius of the Tiszalök Barrage provide an excellent illustration of the situation. My concrete answer to the question is: when technical development is carried out at national economy level it is not politic to present the problem as an alternative, because even today irrigation water must be conducted high above the ground for 50–80 kilometres to be distributed on favourable growing sites, while it would be possible to improve the efficiency of the investment and reduce the prime cost/m^3 of the supplied water by irrigating the intervening area. With selective agricultural development there is no doubt that from the farms' point of view the supplementary investments required for irrigation will probably be returned more rapidly on fertile soils.

ANTAL, E.: At the agrometeorological stations at Szarvas and Keszthely experiments have been carried out for more than ten years to determine the water requirements of various field crops. The trend of water requirement is studied as a function of weather and fertilizer using compensation evapotranspirometers with an area of 4 m^2. The plant stands in evapotranspirometers supplied with 0, 120, 240 and 480 kg/ha NPK active agent were given three kinds of water treatment: natural precipitation, supplementary irrigation, and optimum irrigation. On the basis of the 10-year experiment it was established that with an optimum water supply the maize yield ranged between wide limits in spite of applying the same agrotechnics (identical variety, water and nutrient supply). In each case an increased rate of fertilization resulted in a yield increase (e.g. when the amount of active agent was raised from 240 to 480 kg/ha the yield rose from 103 to 113 q/ha over an average of 7 years), but the annual trend of the yield depended greatly on the air temperature. In the natural precipitation treatments a high rate of fertilization caused a yield depression in dry years (in 1971, for example, the yield, expressed in shelled May corn, was 114 q/ha with 240 kg/ha NPK, but only 101 q/ha with a large dose). In this treatment the yield fluctuation in the individual crop years was higher than in the stand given an optimum water supply. The amount of yield ranged between 73 and 134 q/ha with a medium rate of fertilization (240 kg/ha NPK) and between 78 and 147 q/ha with a large dose (480 kg/ha NPK). Thus, efficiency varies with the weather conditions to a lesser extent if the water supply is optimum, and to a greater extent without irrigation. At the same time, a crop given an optimum water supply produces an economical yield with a medium rate of nutrition, while under dry farming conditions a high rate of fertilization has a compensatory role, except in droughty vegetation periods.

The answer to the question thus follows from the above: soil fertility may be an important aspect of irrigation development, but the nutrient supply (which should be optimum, not maximum!), the climatic and geographic potential, the physical properties of the soil and the cost of the available water resources are of similar importance.

Ács, A.: In my opinion irrigation should be developed on a larger scale on more fertile soils with higher potential productivity. On such soils the efficiency of irrigation is higher. Irrigation increases the absolute amount of yield on soils of low fertility too, but the economic efficiency is doubtful in most cases. I do not agree with the statement that the percentage of irrigated areas in the Great Hungarian Plain is higher due to rice growing. Irrigation is applied to maize, sugar-beet, alfalfa, etc., but not to rice: this crop is flooded and continually covered with water. It is not correct to treat the two as one subject.

Bauer, F.: For national economic reasons I think it is definitely more sensible to develop irrigation on a wider scale on more fertile soils.

Borka, Gy.: Irrigation is profitable primarily in the case of soils with an adequate nutrient level. A harmonious nutrient supply which meets the biological requirements of the plant automatically results in an economic water balance. A doubling of the yield can be produced with much less than double the amount of water if the crop is properly fertilized.

Budavári, K.: Irrigation should first be developed on the more fertile soils of the comparatively dry regions of Hungary (Great Plain, the plains in the northwestern and southeastern parts of Transdanubia), where the amount of precipitation during the vegetation period is less than 350 mm. However, areas with poorer quality soils should not be completely excluded from the irrigation programme, because

- they are particularly sensitive to a shortage of rainfall, so irrigation may result in considerable yield surpluses on these soils, especially in drier years (while rice should only be grown on soils of this type);
- a large proportion of these soils are situated near irrigation canals, so it is relatively cheap to supply them with water (in many cases gravitationally).

Cselőtei, L.: Additional investments, including irrigation, are justified from the point of view of the national economy in those places where they are best utilized. This refers not only to the soils but also to the plants grown. Irrigable soils should thus be judged according to the crops and the production aims.

In the case of rice, for example, at some stage, perhaps already, a decision must be made as to whether the 8—10-fold consumption of irrigation water per ha compared to other crops (e.g. maize, alfalfa, sugar-beet, etc.) is economical in Hungary. Water resources are becoming more and more restricted, and where they are utilized is a matter of some importance. It will be still more so when the price of water approaches its value more closely. Further investments will, of course, be required if irrigation is extended to an 8–10 times larger area to supply water to crops other than rice. Here too, the question will primarily be decided by economic considerations.

Soils must, however, be examined not only for fertility but also for other properties, according to the requirements of the crop in question. It seems, for example, that for certain vegetable crops mechanical harvesting and other operations can be carried out better on sandy or sandy loam soils which dry out quickly after rainfall or irrigation, thus allowing machinery to be used. Since irrigation is in many cases a precondition for growing these plants, water should be brought to such soils as well [Cselőtei, L. (1978b): Új irányok és feladatok a növények vízellátásában (New tendencies and tasks in supplying crops with water). (Academic inaugural lecture.) Agrártud. Közl., **37**, 45–57].

Water is used more efficiently on fertile soils, so considering the costs of water transportation and application, irrigation should be introduced first on areas with "better" soils.

Debreczeni, B.: The intensive development of irrigation on soils with good fertility is in the interests of both the national economy and the farms. Our irrigation and fertilization experiments with winter wheat and maize have proved that on soils well supplied with nutrients the effect of irrigation is better than on less fertile soils.

Frenyó, V.: The answer to the question of whether irrigation should first be applied on poor or on fertile soils is obvious. When the soil has an abundant, balanced supply of nutrients the limiting factor is water, so irrigation farming should be introduced wherever possible. On the other hand, Hungary has provided an example of how to grow flooded rice on infertile alkali soils by using home-bred varieties with shorter vegetation periods and lower heat requirements. Hot summer weather, when crops without irrigation suffer great damage, is the most favourable for rice growing. Alkali soils occupy more than 300,000 ha in Hungary. On such soils the regular irrigation or flooding required for rice production might be expected to promote the leaching of the harmful Na salts; thus, in addition to supplying the plants with water an ameliorative effect might also be obtained. The local conditions must, however, be taken into consideration, and the time and rate of irrigation must be determined so as to prevent the salts dissolved in the deep layers from accumulating in high concentrations in the upper soil layers. There can be no doubt that this requires expertise and a thorough knowledge of the local soil conditions, particularly a chemical analysis of the subsoil and the ground water. Preliminary model experiments might provide a better basis for solving the problem.

The low fertility of alkali soils in some places is mostly due to bad soil structure and the dominance of harmful salts. On the other hand, the reason why exceptionally poor soils are infertile is that the low humus content can only store a small quantity of mineral nutrient. Eroded areas, sand transported by the wind, leached soils, and those whose nutrient content has been depleted will naturally yield little even with irrigation, perhaps even less than without irrigation. It is a well-known fact that if the vegetation is well supplied with water this involves an increased uptake of nutrients. The agrotechnics for irrigated crops must include an increased nutrient supply, i.e. an adequate frequency and higher rate of fertilization.

My answer, in short, is that when irrigation is properly applied to soils abounding in nutrients it is generally advantageous. The irrigation of poor soils, on the other hand, will only be efficient if it is combined with a proper rate of fertilization.

Füri, J.: In the case of grapes, irrigation should in my opinion be developed first on the sandy plantations of the Great Plain, where the water regime of the soil is bad and evapotranspiration is high. Of course, with a view to increasing production as well as maintaining a steady level of yield, on areas with unfavourable precipitation conditions and heavy soils, such as Pécs, Villány, Szekszárd, Badacsony and Eger, and in places where it is desirable to promote the reproduction of *Botrytis cinerea*, such as Tokajhegyalja, irrigation is expedient and economical. In Tokajhegyalja the low intensity sprinkler method of irrigation is recommended in the ripening period, though often summer precipitation must also be supplemented.

GYENGE, J.: Irrigation, as an important factor in agrotechnics, cannot be separated from the environment in which it is applied, so before taking up a position on the question of irrigation development I should like to emphasize the primary importance of rational soil utilization, due to the properties of the soil. Once it has been decided what the soil should be used for, and knowing which crops require a large quantity of water, consideration can be given to the development of irrigation.

I think that when a region, or part of it, is unsuitable for growing crops with high water requirements, or possibly for irrigation itself because of certain properties of the soil, the idea of irrigation development should not be considered even for a moment.

A solution to the questions of production policy and rational land use could result in much greater achievements than highly capital-intensive development that neglects the prevailing conditions. An example of this is the present situation in rice production in Hungary.

Irrigation should definitely be developed on areas with favourable conditions, even at the expense of giving those with poor conditions extra funds from the surplus income obtained as the product of development on favourable areas.

The nutrient level, water regime and low-lying situation of areas with unfavourable conditions create farming conditions which do not permit the production of crops requiring high permanent expenses to be developed, or in some cases even to be considered, nor do they allow risks with highly uncertain results to be taken. Owing to the frequent occurrence of inland waters a high rate of fertilization or the application of chemicals containing triazine are not permitted, among others for environmental protection reasons, since their active substances may be washed out.

However, the steady high costs required by the additional nutrients, the expensive, more active pesticides and the seed of high biological value are an indispensable precondition for rational, up-to-date irrigation farming.

HARMATI, I.: It is generally said that the fight time to introduce irrigation is when the crop can no longer be increased without irrigation even if optimum cultural practices are employed on a given soil. On soils with poor water conditions this point is unfortunately reached at a rather low yield level, which, in addition, varies greatly with the precipitation conditions. Under natural precipitation conditions on soils with an unfavourable water regime the possibilities of production development are very low and uncertain owing to the insufficient utilization of precipitation. Any significant progress towards economic, reliable production can only be made through amelioration and irrigation, which also make it possible to successfully produce crops which at present are quite out of the question. Unfortunately, the majority of soils in Hungary have water conditions that are far from unobjectionable.

Experimental results and practical experience unequivocally prove that the less the amount of precipitation the greater the difference in yield between soils with different water regimes. Water deficiency makes its effect felt earliest and most severely on soils with poor water conditions where it causes the greatest damage. The more unfavourable the water regime of the soil is, i.e. the less useful water it is able to retain, the higher the fluctuation of yield caused by precipitation conditions is. To support the above statements the average yields obtained under different precipitation and soil conditions from 3 maize hybrids grown in a monoculture at the same site with identical agrotechnics are presented below.

Year	Precipitation, mm (Apr.—Sept.)	Total everage water consumption, mm	Grain yield q/ha on meadow soil with a		
			bad	medium	good
			water regime		
1974	337	362	37.5	71.6	84.6
1975	388	421	70.4	84.3	89.6
1976	196	255	18.1	56.7	80.4

It also follows from the above that, with appropriate agrotechnics, irrigation increases the yield to the greatest extent in places where water deficiency occurs earliest and most seriously. This is celarly shown by the following data.

Yield-increasing effect of irrigation on the average of 3 hydrids

Year	Precipitation, mm (Apr.—Sept.)	Irrigation, water, mm	Grain yield surplus q/ha on soil with a bad water regime	Grain yield surplus q/ha on soil with a good water regime	Average
1974	337	120	21.0	13.6	17.3
1975	388	40	−0.2	5.4	2.6
1976	196	200	38.2	17.8	28.0
Average		120	19.7	12.3	16.0

Thus, the yield-increasing effect of irrigation fundamen ally depends, among other things, on the precipitation conditions, and, closely connected with this, on the water regime of the soil. The poorer in precipitation the growth season was, the greater was the difference in yield surplus between the two kinds of soil.

On soils with poorer water conditions amelioration and irrigation have a particularly important role; they greatly increase the yield, reduce the fluctuation, and lessen the ever growing differences between farms working on good and bad soils. As a result the national yield averages can be substantially increased and state subsidies reduced. So, I think that in the case of field crop production and grassland management irrigation should be introduced on as large an area as possible even on poorer quality soils. Prior to this, naturally, the necessary intellectual, financial and technical conditions must be made available.

Horváth, I.: It is very difficult to give an unambiguous answer to this question, because the conclusion which can be drawn from economic considerations is that with the same amount of investment irrigation is more profitable on better quality soils. On the other hand, on poor soils successful farming cannot be carried out at all without irrigation. I think it would be better to divide the question and discuss irrigation and flooding separately. The latter is related with rice growing, for example. These two agrotechnical procedures should be separated because they have highly different water requirements. While irrigation, which is best applied to fertile soils, is influenced by the conditions of precipitation, the water requirement for flooding in rice production, for example, is independent of the precipitation.

Kiss, A. S.: When the poor soil quality is caused by the low water capacity or high dead water ratio of the soil, i.e. by the bad water balance, then the soil should be placed among those to be irrigated first. The more severe the drought the greater the soil-dependent differences in yield. Under non-irrigated conditions the difference in yield between poor and better quality soils may be as much as 60%, while with irrigation it is only about 17%. This shows that the efficiency of irrigation is higher on poor quality soils. This can be explained by the fact that the yield reduction caused by water deficiency occurs sooner if the water balance is bad. This leads to the conclusion that irrigation should be developed to a greater extent on low quality soils.

Kovács, G.: In the 1940s ideas for "nature transformation" dominated irrigation planning in Hungary. The yields were doubled, but this simply meant that instead of 20 q/ha maize grain 35—40 q were perhaps produced, while if the same amount of irrigation water was applied on fertile soils 70 q/ha was obtained instead of 40 q.

It is true that the yield in the latter case was not doubled, but nevertheless, with a smaller amount of water and less possibility of damage more was produced in an absolute sense on irrigated fertile soils. And when maize or alfalfa, for example, were grown on meadow and alkali soils with trickle irrigation in furrows or strips, too much water was occasionally supplied, which caused yield losses, because apart from on rice-growing areas little levelling work was done. The levelled areas prepared for rice production or irrigation (surface irrigation) were ruined in 4—5 years by incorrect ploughing. A rainfall of 10—20 mm immediately after irrigation caused great damage to maize, sugar-beet, alfalfa, etc. A long list could be compiled of the crops which suffered from such excesses of water. For the sake of a quick solution water was supplided through the drainage canals, so if there was a sudden downpour the irrigation water in the canal prevented drainage from taking place.

LELLEY, J.: Irrigation should primarily be developed on those areas where it will be utilized most economically. Exceptions are poorer soils, the quality of which can be permanently improved by irrigation. In such places, due to the long-range objectives, preference must be given to irrigation. Thus, irrigation must first be developed on areas where it will be most economical, but short-term results should not always be the decisive factor; the long-term advantages offered by irrigation must also be considered.

LŐRINCZ, J.: There is no doubt that irrigation should first be developed on more fertile soils such as chernozem and some meadow soils, as irrigation is more efficient in such cases. It is common knowledge that on alkali soils and on salt affected soils irrigation may cause serious damage. In the case of forest soils, which in Hungary are mostly situated on slopes, erosion may occur as a consequence of irrigation. Of course, if there is a shortage of irrigation water, it is better to use it where it yields the largest profit. The damage caused by alkalinity and erosion can be considerably reduced by supplying the correct amount of water.

MIHÁLYFALVY, I.: This is not an easy question to settle. In irrigation trials carried out with field crops for several years better relative results were obtained on meadow soils than on grassland soils. On the other hand, the absolute yield surplus obtained as a result of irrigation was larger on the latter soil type. If the development of irrigation in farms with poorer soils and a lower level of production is neglected, the production and income differences between farms with good and low productivity will continue to increase, and irrigation investments will become still higher, as the water will have to be transported over greater distances. In my opinion the thoroughly considered requirements of the farms and the economical utilization of the available irrigation water should form the starting point in irrigation development. It is also true that prosperous farms overcome the difficulties involved with irrigation more easily than the farms with low productivity do. Wide experience has been gained in this field recently.

NÉMETH, S.: This is a much-debated point: whether to develop irrigation on poor or on fertile soils. In my opinion the problem cannot be simplified to this extent, particularly when it is considered at national economy level. Before deciding on the regional development of irrigation, the river systems, economic conditions, type of production, etc. of the region must be subjected to a complex examination, as must the highly important question of soil fertility, as was initiated by the Agricultural Development Office of the Tisza Region at the end of the sixties.

PÁSZTOR, K.: Irrigation should first be developed on a larger scale on fertile soils because it is here that the conditions for favourable water utilization can be provided. Where necessary, a much cheaper investment would be to promote better water conditions in the soil by melioration through drainage.

On areas with poor soils, where rice can be economically grown, irrigation must naturally be made possible. But in places where it does not require substantial investments, the question of irrigating sandy soils must also be considered. At the same time, both the subjective and objective conditions for the better utilization of water (professional training, drainage and other melioration work, up-to-date agrotechnics, etc.) must be created, which means a cheaper and more lasting investment than irrigation.

PETRASOVITS, I.: This is an extremely complex question to which only a highly differentiated answer can be given even at the level of the national economy.

In the 1940s the fact that a large proportion of the irrigation area was on low fertility soils was not directly or even mainly due to the poor precipitation conditions. The reason was not primarily of a climatic nature. It was a question of interaction between several conditions and causes. The primary cause was the introduction of rice, a new hygrophytic species, in commercial production. This was made possible by the successful selection and breeding carried out since 1933 by Obermayer, Somorjai, Szelényi and Frank. Another cause was the nutrition and marketing boom during World War II. And finally, the existence of extensive, unprofitable alkali areas on the

Great Hungarian Plain, a region relatively rich in heat and light, and the fact that there were free water resources near these areas in the Tisza—Körös valley. When developing irrigation both in the present and in the future this historical background and the natural geographic conditions must be taken into consideration. A large proportion of the soils in the vicinity of water resources in Hungary are of poor fertility. It is debatable whether the transportation of irrigation water to good soils at some distance is economical (owing to the investment costs and losses due to leakage and evaporation).

On "good" soils the irrigation demand index is lower, because water retention in the soil may be as much as 250—350 mm in a 1 m profile compared to the 100—150 mm water retention of "poor" soils.

Furthermore, the lower irrigation requirement of good soils means that the capacity of the irrigation systems will be less profitably exploited than on poor soils, given the same crop structure.

Irrigation should be included in the complex process of amelioration, since it may happen that low fertility soils, when improved in some way or other, will become competitive with good soils. Moreover, irrigation may threaten to reduce the fertility of "good" soils, particularly in the case of a possible secondary alkalization.

Thus, taking into consideration the fertility of the soil, land use objectives and the availability of water resources, irrigation should, in my opinion, be introduced primarily on those farms where the general level of management will make it profitable. However, partly for historical reasons, it is not usually on poorly fertile soils that profitability develops favourably. Nevertheless, in the system of ecological, technological, economic and political relations the extent of irrigation development in different areas must not be determined by the fertility of the soil alone.

Pletser, J.: The irrigation area can only be extended together with an increase in the rate of fertilization. At the end of the 1940s the national average for fertilizer utilization was as low as 5 kg/ha active agent. By 1975 this amount increased to 276 kg and has remained at about the same level ever since. This is what has made the extension of the irrigation area possible. The possibilities of irrigation must be exploited in all cases where the structure of the soil renders it possible. The fertility of the soil can be influenced by means of artificial fertilization, and fertilizer conversion greatly depends on the water regime of the soil.

Posgay, E.: The question of what soils it is worth developing irrigation on can be approached from several points of view.

Let us begin with the most obvious condition, the euestion of the water supply. To speak of soils with good or poor fertility is not sufficiently exact. It would be more correct to speak of soils with a good or poor water regime, i.e. of soils able to retain a large or small amount of water for the plants, particularly as the available nutrient content of the soil can more readily be controlled by man (by means of fertilization). In this field highly favourable changes have also been observed over the last twenty years in practice.

In soils with a poorer water regime less water is available for the plants, so water deficiency occurs sooner. This means that drought causes a greater reduction in yield and water supplementation through irrigation is needed more often. It is here, though, that internal water can cause the most damage, by creating a two-phase condition in the soil. This has important consequences for irrigation and inland drainage alike. Thus, it follows that on soils with a poorer water regime both the potential importance and the effect of irrigation are greater.

At the same time, if the present financial state of the national economy and the farms is taken into consideration, it is found that farms with a poorer water regime, i.e. less fertile soils, are not in the financial position to make irrigation investments. If this were undertaken by the national economy, the same government contribution would only be sufficient to introduce irrigation on a much smaller area than if irrigation were developed on farms with fertile soils, where a considerable proportion of the costs could be covered by the farm.

I am convinced that sooner or later the water resources, including the water regime of the soil, will be given more consideration when developing irrigation.

Pozsár, B.: In many states of the USA and especially in California record yields have been obtained on structureless sandy soils, i.e. on the poorest drift sand, by means of irrigation and, naturally, macro- and micro-element replacement: 144 q/ha Mexican wheat, 128 q/ha Triticale, 167 q/ha maize, etc. Vegetable growing on a farm scale in hydroponic cultures has also been solved. It is only in structureless sand that the irrigation water does not ruin the soil structure, and alkalization also appears much later than in soils with higher fertility. A great many examples of subsoil irrigation where large yields are planned have already been demonstrated.

SHMILLIÁR, M.: The correct management of water resources co-ordinated with various agrotechnical procedures improves the fertility of the soil, though perhaps more economically in good, and less economically in poor soils.

In my opinion there is a tendency for differences between yield levels to decrease, and in the long run they will be negligible. This is why I attach so much importance to irrigation; this is why it must be developed wherever possible. The subject of an earlier round-table conference included the growth of the population and the problem of supplying the increased population with food. Calculations show that the yields of field crops must be roughly doubled, and one of the most important preconditions for this is wise water management, whether the soil in question has good or poor fertility.

SOMOS, A.: Calculating only at national economy level, the development of irrigation seems to be most justified on soils where it will be more efficient. This can perhaps be accepted as a general principle. It seems likely, however, that the efficiency calculations do not take all the factors into consideration. If a policy of this nature were consistently carried out the differences in profitability between farms with good and poor soils would increase, which would almost certainly lead to the latter being closed down. The additional costs involved with the establishment of new jobs, new housing, etc. are certainly not included in the efficiency calculations.

SZABÓ, B.: The irrigation plants constructed in earlier years were established with the exclusive aim of using them mainly for rice growing. This was indeed the case years ago, so when attempts were made to grow other plants on these areas this form of irrigation could not be applied with a satifactory degree of efficiency. In this respect the development carried out in that period was very one-sided, and has now been almost completely abandoned or reconstructed. On these low fertility soils large investments should not be made, in my opinion. These soils are so-called "minute soils", i.e. the period for which the soil cultivation is optimum is very short, but so is the irrigation time.

Another, peculiarity of these soils is that on each occasion only a small amount of irrigation water (15—20 mm) should be applied, in tiny drops at low intensity; otherwise the soil becomes liquid and shrinks considerably during drying, which means that the life conditions of the plants will not be satisfactory.

For this reason irrigation water should first be supplied on the best soils, at a level high enough to prevent yield losses caused by water deficiency. Thus, the order in which irrigation development in the country is carried out should be primarily determined by the quality of the soil.

SZABÓ, L. GY.: It is worth developing irrigation on a larger scale on better quality soils. The cultivation level of the soil must continually be improved (to achieve minimum tillage or no tillage).

SZALAI, GY.: In my opinion it has always made sense to utilize the low yielding soils of the Great Hungarian Plain for rice production. At the same time, in the case of other field crops irrigation should be developed first of all on fertile soils, as the yield surplus obtained by irrigation is larger here; consequently, the additional costs of irrigation and the development work connected with it give more efficient returns on good soils. However, this does not mean that the (relatively cheap) flooding irrigation of alkali pastures is uneconomical.

SZALÓKI, S.: The question of whether irrigation should first be developed on soils with better or poorer fertility is not a simple one.

In my opinion the question has not been properly put.

The fertility of soils is a complex characteristic which depends on many factors and is not even constant. It is common knowledge that soil which is unsuitable for some crops may be good or even excellent for others, or can at least be made fertile by means of systematic, planned regulation of the nutrient and water levels.

It is sufficient to mention that in the region between the Danube and the Tisza, which was once an infertile desert, beautiful plantations now grow. Moreover, with the use of irrigation high yield averages can be attained in vegetable and field crops as well.

On the other hand, there are soils in Hungary which owe their high fertility mainly to the good natural water supply.

Thus, when planning the regional development of irrigation the present fertility of the soil is not the only starting-point; the prospective efficiency of irrigation is a more important factor, and this is influenced not only by the fertility of the soil but also by the aims, structure and level of production, the extent and frequency of the water deficiency, the size of investment required, etc.

SZIKI, G.: I have no quarrel with the question, but I should like to make a division in time.

In the present period, considering the restricted nature of investments, if reproduction is to be achieved on an increasing scale there must be a return on the investments made as quickly and as reliably as possible.

As regards irrigation, this can be achieved most reliably and at the lowest cost on soils of high fertility.

It is also true, however, as proved by experience in recent decades, that up-to-date irrigation development can only be carried out economically by establishing large irrigation systems on uniform, hydrographically interconnected areas. Considering the varying soil conditions in Hungary, often even within a relatively small area, soils irrigation systems. Only the ratio of good to poor soil can be more or less favourable. It is obvious that in such cases the more favourable ratio should be chosen, though taking other viewpoints too into consideration, there is rarely a choice, especially in Hungary. On technical and economic considerations, and reckoning with the near and distant future alike, it would be a great mistake when designing and constructing to ignore larger or smaller pockets of less fertile soil within the area of the irrigation system. Main, secondary and inter-farm water-conduits and other structures, which often have a part in the operation of the whole system, must be constructed in these places, too. Only the establishment of farm equipment serving directly for irrigation purposes can be put off in order to equip more efficiently better soils promising more success and thereby to be able to utilize these areas sooner.

It is quite another matter, whether, once the basic construction work has been completed and the water is available on site, it is worth excluding less fertile areas from the irrigation system instead of increasing the fertility of these areas by appropriate soil amelioration carried out with additional investments; and if so, for how long. In my opinion any controversy in this matter can only be a question of dates, which should be decided by the economists. The fact that these areas should also be utilized by means of irrigation is beyond doubt, the only question is: when?

As to the future: all lands including the poorest ones must undoubtedly be utilized, and a considerable proportion of them must be irrigated, since the availability of land is restricted and, unfortunately, is slowly but surely becoming more so. When it will become necessary and possible to introduce irrigation on these areas, depends on a great many factors, the discussion of which here would lead us too far from the subject in hand.

Every effort must certainly be made, taking the above arguments into consideration, to set up irrigation systems first on areas with fertile soils, though — like many other principles — this is not of general and eternal validity.

It is known that in countries such as Denmark, Holland, etc., where the agricultural area is just as restricted, if not more so, as in Hungary, soils less fertile than Hungarian soils have nevertheless been utilized for a long time. After initial large investments, farming is carried out on these areas at a high level at considerable cost. It is true that the financial means required for the realization of such tasks have accumulated in these countries in the course of history, while in Hungary they must be created now by means of hard work. However, the endeavour to utilize soils of low fertility, if necessary with the help of irrigation, is undoubtedly wise. Here again, the only question is: when, which depends on a great many factors. But it cannot be denied, that the task might be realized sooner if irrigation were first introduced and made profitable on soils of high fertility.

SZILÁRD, GY.: Some 60% of the irrigation area in Hungary is situated in regions with unfavourable agricultural conditions.

This situation has arisen mainly because of the way in which irrigation development has been judged and of the role which has been assigned to it.

Before the end of World War II and even later, up to the sixties, irrigation development was regarded as a means for improving rice production, overcoming drought and assisting farms with low productivity.

In addition, water management officials considered it their main task to develop main water works first of all in places where the supply of irrigation water to agricultural establishments could be ensured with the most economic solution: by gravitation. These were also the areas which were threatened most seriously by the absence of amelioration. The improvement of rice production, the geographic position of arms with low productivity and the possibility of conducting water by gravitation all had a part in causing the development of irrigation to be carried out mostly on alkali, heavy meadow clay soils. The development of loess grassland soils was pushed into the background, since on these areas drought had a different effect, the farming standard was higher than the national average, and the specific investment costs of irrigation development were also higher than in the case of water conveyance by gravitation. Generally, higher lying areas could only be supplied with irrigation water by means of pumps, often overcoming a 20—50 m elevation. The development work done on soils with good and poor fertility was not examined more closely from the point of view of profitability.

The location of irrigation areas was also influenced by the system of state subsidies in force at the time, and by the dominant role of surface irrigation rather than other irrigation methods. As a result of all this, a survey made in 1968 by the Central Committee for People's Control showed an increase of 5.8 cereal units/cad. yoke in favour of irrigation farming. This is no negligible result, since this surplus was obtained at the time of the socialist reorganization of agriculture in Hungary, and contributed to domestic supplies to the population. In 1966—68 the development of irrigation was redirected on new lines, the most important principles of which are summed up below.

— Irrigation can be most efficiently developed in those places where the natura (ground-water regime) and economic conditions are suitable for it.
— Irrigation is best introduced or developed when the production and farming standards reach or approach the level economically attainable under dry farming conditions, and when the amount and distribution of natural precipitation is not sufficient in practice for the extension of production. This is the point where, of the major factors required for a further increase in production, water becomes a minimum factor.
— Permanent large yields can only be obtained when all the factors required for the development of the plant are continuously and simultaneously provided in the necessary quantity and quality.
— Prior to or at least simultaneously with the development of irrigation, the field and road systems of the farm should be reorganized according to the requirements of complex water management.

Reasons for developing irrigation on fertile soils

1. According to a survey made by the Agrochemical and Soil Research Institute of the Hungarian Academy of Sciences, on 59.5% of the agriculturally cultivated area of Hungary there are factors (acidic reaction, alkalization or clay content, marshy character, erosion, etc.) which for various reasons limit the fertility of the soil. According to another study prepared by the same institute, only 15% of the area of Hungary is suitable for irrigation without any reservations, while 15% can in no circumstances be irrigated. On the remaining 70% various agrotechnical and technological measures must precede the introduction of irrigation, to prevent the occurrence of harmful procerses in the life of the soil.
2. It is a well-known fact that 95% of the surface waters of Hungary originate in other countries. The amount of water draw-off abroad is increasing, mainly because of the rising level of industrial and agricultural development and the demand for water supplies for the population. Calculations taking a long period of development into consideration show that even in 50 years' time, when, according to the present plans, the development of the main water works and the construction of the reservoirs necessary to ensure a steady domestic water supply will be completed, it will still only be possible to carry out irrigation farming on some 1—1.2 million hectares, 20—25% of the expected area of agricultural production.

3. While processing the 1976 results from irrigation farms the Irrigation Eesearch Institute, Szarvas, examined the trend of farm indices as a function of land quality. To characterize the land quality the value in gold crowns/ha was used. (The changes in the value of the gold crown do not fully reflect land quality, but more reliable indices are not available.) The following results were obtained:

Indices	Below 15.0 gold crowns/ha	15.0—19.9	20.0—24.9	Above 25.0 gold crowns/ha
Capital ratio, Ft/ha	24.047	29.750	31.193	33.959
Total production value, Ft/ha	19.719	22.700	25.473	30.076
Value of crop production, Ft/ha	7.757	9.665	11.854	14.020
Value of basic activity, Ft/ha	14.934	18.250	20.928	25.304
Net income, Ft/ha	1.644	1.544	2.324	2.719
Production value per worker, Ft/head	179.358	202.149	218.928	243.526
Cost level	83.8	81.2	76.6	73.8

These data also show that irrigation development should be given priority on areas with good soil conditions.

4. In the irrigation development plans up to 1990 the main objective is to stabilize the production of rice, potatoes, seed production, sugar-beet, vegetables and the highly valuable vine and fruit plantations, and to increase the specific yields to the following values:

rice	32 q/ha
potatoes	250—300 q/ha
sugar-beet	480—550 q/ha
tomatoes	350 q/ha.

These yields can only be produced by farms with favourable natural conditions, a high technical level and a good capital ratio.

5. Besides increasing the volume of production there is now a growing demand for production reliability, i.e. for maintaining the attained level of production.

Under non-irrigated conditions it is again in farms with better natural conditions that the maximum level of production possible in irrigation farming is attained, and this is why the introduction of irrigation in these farms is becoming urgent, since all the other possibilities of increasing production have been exploited already. It is here that the tendency not only to raise the level of production but also to make it more reliable can be observed. Yield reliability is becoming a basic requirement because of the rapid increase in production costs. The wide fluctuation in precipitation both from year to year and within the growth season is, together with damage caused by the forces of nature, the most important element of risk in the production process.

It is therefore reasonable to develop irrigation first of all on these areas, on farms with a high level of production.

The Ministry of Agriculture and Food, in co-operation with the National Water Authority, has elaborated a long-term development plan (up to 1990) for water management in agriculture, according to which irrigation will be developed on about 300 thousand ha, and some 400 thousand ha of the existing facilities will be reconstructed.

The production development objectives, the soil conditions of the country, the limited nature of the water resources and the economic effects of development on good and poor soils all show that with the exception of rice and natural grasslands, which have special needs and characters, the development of irrigation should be carried out on areas with good soil conditions, for reasons of national economy and management alike. In farms situated on areas with poor soil conditions, where the highest yield level possible under dry farming conditions has not yet been reached, other means of production development (nutrient management, variety, mechanization, amelioration, etc.) should be improved before introducing a system of irrigation farming.

These principles are justified by the history of irrigation in Hungary and the conclusions drawn from it.

TÓTH, M.: As is well known, Hungary is poor in water, and the possibilities of supplying water (reservoirs, dams, aqueducts) are not favourable either. This situation limits the possibility of irrigation and makes its introduction expensive.

For many reasons, of Hungary's two important water systems (the Danube and the Tisza) it is the Tisza that must be more rapidly developed. Even if Hungary's irrigation possibilities are fully exploited, about 60% of the country's irrigated area is situated in the region east of the River Tisza. In this region soils with low fertility (alkali soils, etc.) are found on relatively large areas. For economic and technical reasons (water consumption, water transport) earlier attempts at irrigation on many soils with low fertility in this area gave poor economic results.

To achieve the highest possible efficiency in irrigation, and indeed for all investments, the most fertile soils should primarily be irrigated (in the largest proportion). The economic criterion is that irrigation investments should be proportionate to the expected economic result. For example, on grassland with poor quality soil irrigation should be introduced with a technical solution requiring cheap investment and low annual operation costs.

UJVÁROSI, M.: I think the question of whether poor or fertile soils should be given priority in irrigation planning, which has been debated ever since the forties, has now been decided. Even the role of rice production has completely changed now. Since it costs at least as much to provide the facilities required for irrigation on bad as on good quality soils, it is obvious that irrigation should first be introduced on areas where it produces the higher value. In addition, on more fertile soils less water is required for supplementary irrigation than on less fertile soils, where in most cases the condition of the soil is such that the yields will be smaller in spite of irrigation. Irrigation must therefore be given priority on more fertile soils which, with the same investment but a lower production input, will give larger (and more importantly, reliably large) yields, thereby providing higher incomes.

At the same time rice production cannot, of course, be abandoned to the extent demanded by the interests of the national economy. For various economic and political reasons the development of irrigation on less fertile areas cannot be neglected either, but this work should be done at a slower rate. To create irrigation facilities requires enormous national economic investments. Since our resources are far from being unlimited, irrigation facilities should first be created where quicker, higher returns can be expected.

VARGA, GY.: Considering the demands of horticultural production it would be advisable to develop irrigation on a larger scale on soils with higher fertility in the first place. Besides the fertility of the soil, however, other natural and economic factors must also be taken into account. The climatic conditions, particularly the local temperature, the physical structure of the soil, etc. have an influence on the efficiency of irrigation, depending on the variety grown. With a view to the earliness and quality of the crop, and the better scheduling of the harvesting operations, warmer areas, with sandy or sandy loam soils, which warm up quickly and have high capillarity, are more favourable for the irrigated production of vegetable crops.

VÁNCSA, J.: Farm management is definitely influenced by the quality of the land, which is a fundamental instrument in farming. This applies to irrigated farms as well. After the end of World War II, due to the favourable tendency of the rice market, rice production was the aim of irrigation development in the Great Hungarian Plain. The rice-growing farms were located on soils with poor productivity. Besides rice production, irrigation was also developed, using mainly surface methods, for field crops grown near the rice fields on low-lying meadow soils sensitive to drought. Consequently, 30% of the irrigated farms possess irrigable land of a value below 15 gold crowns per ha, which makes up 12% of the total irrigation area. Rice is still produced even today on more than half this area.

Studying the efficiency of irrigation farming, it is found that an overwhelming proportion of those irrigated farms which show poor economic results, are cultivating land with a value of 15 gold crowns. On the other hand, it can also be demonstrated that the farming activity and economic efficiency of irrigated farms attaining good and excellent management levels were practically the same between the values of 17 and 27 gold crowns/ha. Thus, under irrigated conditions on land with a value above 17 gold crowns/ha the quality of the soil plays a less important, or even completely negligible, role.

Hence, taking into consideration the production aims and the branches of cultivation, irrigation should primarily be developed on soils with better water regimes.

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PÁL, GY.: **Precipitation during the vegetation period (from 1st April to 30th September) ranges between 300 and 350 mm in most parts of Hungary, and in 3 out of 4 years only 275—300 mm can be reckoned with in the centre of the Great Plain. The critical stage of development for most cultivated plants, when the water requirement is the highest, falls within this period. In your opinion, should the irrigation systems be adjusted in the future to the water demand in the critical period of the crops, or should they be kept below that level for economic reasons?**

ALMÁSI, T.: Irrigation development, taking the farm background into consideration too, has a history of a quarter of a century. The efforts made particularly over the last fifteen years offered wide possibilities for the improvement of irrigation systems with different technical and economic parameters. The investment, energy, metal, manual labour and cost requirements of the different systems vary greatly. The limited amount of agricultural area available in Hungary means that special consideration must be given to the utilization of canals and other water works. In relation to all these factors the cost of irrigation as a service depends largely on the degree to which the facilities are utilized. (Even with the simplest equipment the ratio of permanent costs to the total annual cost is about 30%.) Irrigation carried out with the so-called "fire-fighting" method is, in my opinion, the most expensive of all, since it is not only unsystematic, but is usually carried out long after the biologically optimum time, has no yield-increasing effect, and its economic efficiency is questionable. If during its technical development a farm has found the introduction of irrigation to be necessary and has

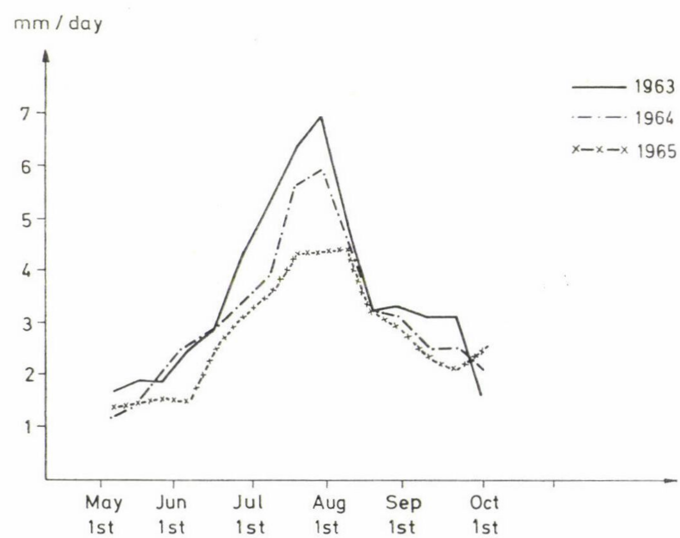


Fig. 2. Daily trend of water requirement for maize canopies in different years

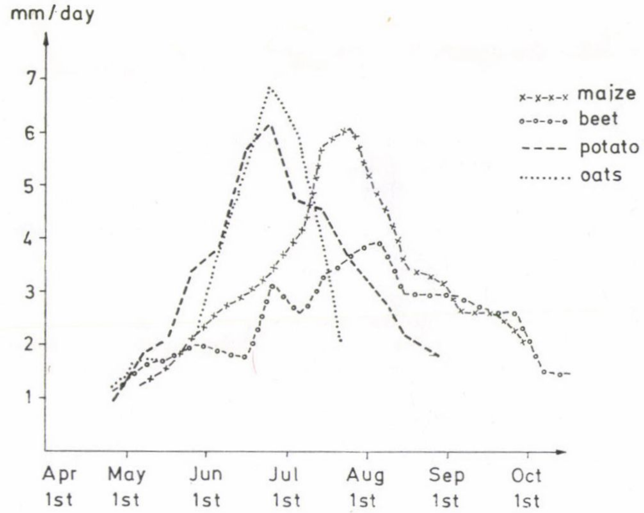


Fig. 3. Changes in the daily water requirements of various plant canopies during the vegetation period in 1964

also spent a considerable sum on the equipment, it is very irresponsible to wait for a period when the critical water demand coincides with the critical water supply on economic grounds. The exploitation of the equipment outside the growth season (preliminary irrigation, storage irrigation, irrigation for frost protection or pest control, etc.) improves the economic efficiency of the equipment.

ANTAL, E.: According to our evapotranspirometer studies (1963—1978) the critical development period of the plant coincides with its maximum water requirement (Figs 2, 3). The water deficiency maximum may, however, shift as a function of the precipitation, the water content in the root zone and the date of maximum water requirement, and may occur at a different time each year; nevertheless, over the average of many years it coincides with the water requirement in the critical development stage. It is a peculiarity of our climate that in dry or droughty years the water requirement of the plants is high, while there is a serious water deficiency owing to the scarcity of precipitation; but this also holds true in reverse: in cool, rainy years, when the plants require less water, the demand for irrigation water is also lower, while water is available in abundance. On these considerations the irrigation systems should be planned to cover a probable water requirement of less than 100%, somewhere in the region of 75%. And in every case economic calculations taking all the factors into consideration should be made before designing the irrigation system of a given area.

ÁCS, A.: This question is similar to that arising in connection with the optimum mechanization level of farms. With the present farm structure traction power is most badly needed in October. In the ideal case all outdoor operations, incuding autumn ploughing, would be completed by the end of October. Mechanization cannot be economically planned to meet this requirement, because the capacity would then be unexploited in 11 months of the year.

In the case of irrigation the peak periods are not so pressing either; if the work is properly organized the process of irrigation can be distributed more evenly. It follows, that since the plants have some tolerance, the irrigation capacity need not be adjusted to the one or two months of the peak period; the level where the system will be in constant use must be approached instead, with a certain margin for safety.

BALLA, L.: For a while it is not likely to be possible to satisfy the water demands of all the agricultural crops of Hungary in the dry periods. Under the present conditions we must be content with helping the crops through the critical periods by applying supplementary irrigation primarily in fields where it is most badly needed. In the more distant future, however, a further extension of the irrigated areas may become necessary and economical, depending on how Hungarian and international economic conditions develop.

Borka, Gy.: We have not yet reached the level where irrigation systems can be designed everywhere to meet the absolute water requirements of the plants. This would be the most profitable solution if the costs allowed it.

Budavári, K.: The irrigation systems should be planned to give a water output less than the biologically optimum water demand of the plants in the critical phase of development, since if the amount of water is 10—20% less than the optimum the yield will only be slightly reduced. Furthermore, the fact that the critical periods of different plant species, or even of varieties, do not coincide must also be taken into consideration; due to the sowing structure certain parts of the irrigation area need not be irrigated during the critical periods of the main crops, etc.

Cselőtei, L.: As regards the water supply, plants may have several critical periods of development. The question refers to the current practice of so-called supplementary irrigation, designed to fulfil the water requirements of the plant in the main period of water uptake. I feel that here, as in all aspects of farming, the economical rather than the potential fulfilment of plant requirements should be aimed at. This applies to irrigation, too. For highly valuable vegetable crops, which are sinsitive from the point of view of the water supply, irrigation in Hungary is usually planned allowing for a 75—80% probability of precipitation. In practice this means that in two out of ten years the water requirements of the plants cannot be met, while in seven out of ten years the irrigation systems are not fully exploited (Fig. 1).

This statement is naturally only true when it refers to a single crop. However, a farm generally produces — and irrigates — more than one crop, or different varieties of the same plant species, the critical development phases of which do not coincide. The irrigation systems are usually designed so that the water supply can be concentrated on places or crops where it will be most efficiently used, either within the farm or between farms. How the irrigation water can be most economically used must thus be decided each year anew, according to the given conditions (Table 1).

Frenyó, V.: The critical development phase of plants is mostly connected with accelerated growth. In such cases the water demand is greatly increased. In cereals tillering and shooting require large quantities of water. This is partly because in these phases of development the volume of the plant grows rapidly, which is not possible if there is a deficiency of water in the cells, because of decreased turgor, for instance. Another reason for the increased water consumption in these development phases is the increase in the evaporating surface. In Hungary the water consumption of wheat is the highest

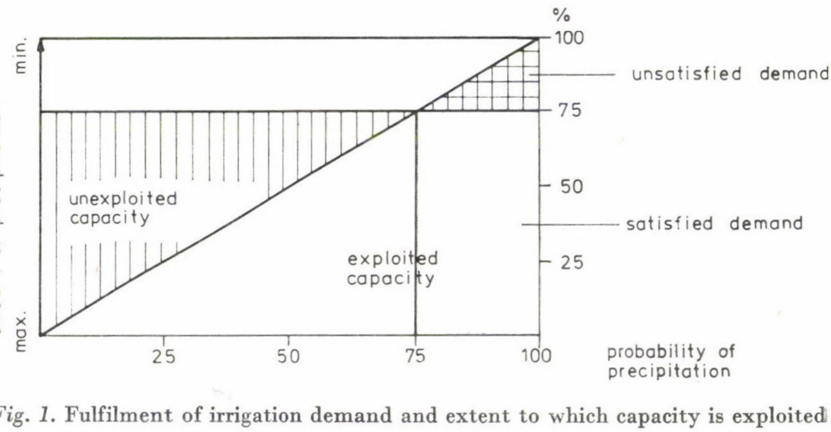


Fig. 1. Fulfilment of irrigation demand and extent to which capacity is exploited

in May. According to a survey made by F. Balázs the amount of water transpired in two days by 1 hectare of wheat (2.5 million plants) in the middle of May was 111 m^3. As the saying goes: Rain in May is worth gold.

On the Great Plain rainfall is most uncertain in July, just when maize and potatoes demand an abundance of precipitation. The later a variety matures, the slower its development and the more it is threatened by drought in July. This danger can be averted by applying a relatively low rate of irrigation in good time.

Another critical phase of development in maize is the flowering period. The pollen tube has a long distance to cover before it reaches the ovule through the long beard-like styles. A dry atmosphere reduces the chances of fertilization, and thus decreases the yield. The maize plant always responds well to irrigation. The first irrigation is best carried out at the time of tasselling and the second when the styles are drying. A third irrigation applied later delays maturation, but if the weather is fine it increases the yield by 6—8%.

Water consumption in the beet field is the largest at the end of July and the beginning of August. The peak, with an average of 4—4.5 litres/m^2 a day, i.e. at least 40 m^3/ha, occurs around 5th August. By the end of October this value falls to a half. It is obvious that irrigation should be adjusted to the maximum water consumption. The irrigation systems should be planned so that they are capable of satisfying the maximum water demand expected in the critical periods. If this point is overlooked, the whole irrigation season may become economically inefficient.

Füri, J.: Irrigation systems must definitely be planned according to the water requirements in the critical periods of the plants grown. In the case of grapes this lasts from flowering to sprouting (from about 10th June to 31st July).

Gyenge, J.: Wherever irrigation can be economically applied as part of the agrotechnics, owing to the soil conditions, the irrigation capacity must be adjusted in the future to the water requirements of the plants during the critical period of development. On these areas every effort should be made to attain maximum yields, and the potential productivity of the plant species and varieties must be exploited. These areas are able to tolerate occasional "over-irrigation" brought about by unexpected abundant rainfall.

Nevertheless, an increase in the efficiency of irrigation (and in fact irrigation itself) postulates:

— an extremely high level of nutrient management, which will thus be expensive,
— very careful plant protection,
— the use of seed of high biological value,
— the correct method of soil cultivation, and
— a capital equipment ratio which will ensure these conditions whatever the circumstances.

These components result in a permanently high cost level, and such substantial investments should definitely not be put at risk. If the existing irrigation capacities are used according to need these investments will not only be refunded but will also yield a considerable profit. With a view to successful farming, irrigation on these areas must therefore become an integral part of the agrotechnics, and the capacity should be planned according to the water requirements of the plants during the critical period of development.

Harmati, I.: The highest irrigation efficiency is attained when the water requirements of the plants are satisfied curing the critical phase of development. This is the most important criterion of successful irrigation farming. Irrigation before and after the critical phase of development only has fundamental importance in the case of severe drought.

Horváth, I.: If the economic aspects render it possible, the operation of the irrigation system should be adjusted to the water requirements of the crops.

Kiss, A. S.: Irrigation is not just a protection against drought, but is also a precondition for reliable crop production. As the soil water content increases the yield increases rapidly at first and later moderately. Excessive irrigation (flooding) results in reduced respiration and water uptake and consequently in a yield decrease. Plants which are tolerant to an over-abundance of water give different metabolic responses to oxygen deficiencies. Experiments carried out with soils saturated with water to different levels showed that the increase in the dry matter production of plants was acceptable up to a moisture content of 65—75% of the water capacity. Thus, during irrigation, the root zone need not be fully saturated with water. The free water capacity ensures that water from any rainfall which may occur can be adsorbed. In this way the harmful temporary shortage of air and leaching of nutrients which might be caused by an unexpected rainfall can be prevented. For economic reasons it is suggested that the moisture level be kept at about 60% of the water capacity. This, however, necessitates the regular measurement of the soil water level, at best automatization.

KOVÁCS, G.: Irrigation is not a separate agrotechnical activity. It must form an integral part of the crop growing operations, but it is primarily an economic question. Irrigation should be developed where the yield can no longer be increased without an additional water supply. A financial contribution by the farm is absolutely necessary, so that the farm will be interested in making the investment pay. This does not mean that irrigation is exclusively the duty of the farm: it is in the interests of the national economy as well, but in my opinion, if the farms are financially interested, the basic conception formulated during the construction of the Tisza-II barrage, namely, that irrigation water should be supplied to the most fertile soils with a view to certain refunding and an economical increase in yield averages, still holds true today. Such soils are the loess tables in the counties of Hajdú-Bihar and Békés, and some poor meadow and alkali soils in the immediate vicinity; the latter have a secondary role: once the irrigation water is there it is utilized for supplying meadows and pastures with water.

Hot-air factories for making green meal cannot be fully exploited without irrigation; the yield of non-irrigated alfalfa fields depends on the amount of precipitation. Again, in potato farms working with the most up-to-date machines and seed-potatoes a 300 q/ha yield can only be reliably obtained with irrigation. It is difficult to see how a modern apple or vine plantation, which requires a considerable amount of investment, (could be profitable without irrigation (including irrigation against frost and for other special purposes).

In places where a high level of farming activity is carried on over a large area and where yield surpluses cannot be profitably increased without water the development of irrigation is and will be necessary and reasonable. In the sixth five-year plant period the introduction of irrigation systems or a change to regular irrigation are required by farms such as the Agricultural Combinate, Bábolna, Agárd, the district of Mezőfalva, Boly, the Hajdúság Agricultural and Industrial Union, the Békéscsaba Agricultural and Industrial Union, etc. These examples clearly show the economic sensitivity of irrigation. In the same way, it would be difficult to cover the sugar-beet requirements of the Sugar Factory at Kaba anywhere but on nearby irrigated areas, due to the high costs of transportation.

KOZMA, F.: In the centre of the Great Hungarian Plain, where the highest water requirement of the plants generally coincides with a period poor in precipitation, irrigation systems should be planned to satisfy the water requirement, which does not mean that they cannot be economical.

In the Great Plain, where the natural water resources are scarce, and particularly in the region between the Danube and the Tisza, irrigation can only be economically efficient if the actual water requirement of the crop to be irrigated is known and the rate and time of irrigation are adjusted accordingly.

Today the water requirements of most of the agricultural and horticultural plants grown in Hungary are already known and the right amount of irrigation water can thus be determined.

In the region between the Danube and the Tisza, where drought often occurs, there are periods even in growth seasons relatively well supplied with precipitation (mainly on quickly drying sandy soils) when irrigation is needed.

The results of water balance studies between 1971 and 1976 also prove that on sandy lowland areas even the vine, a plant generally known to have a medium water demand, requires irrigation. Knowing the rhythm of water consumption in the grapevine, average data can be used in designing economical irrigation systems, which on the sand-table of the Great Plain includes designing and constructing irrigation wells with an adequate water discharge.

The water deficiency in vines on the Great Plain showed the following trend on a six-year (1971–1976) average:

b–f	f–s	s–r	r–l	b–l
3	48	49	19	119 mm

Thus, over an average of six years water deficiency in the vegetation period (from bud bursting to leaf abscision) is 119 mm, of which 3% occurs between bud bursting and flowering (b—f), 40% between flowering and sprouting (f—s), 41% between sprouting and ripening (s—r) and 16% between ripening and leaf abscision (r—l). Detailed investigations have revealed that the highest water deficiency usually occurs in the short phase following sprouting and preceding ripening. It is in this short period that the grape-vine has the highest water requirement and generally the lowest natural water supply.

LELLEY, J.: The precipitation conditions in Hungary are not extreme enough to make it necessary to prepare for full supplies of water during the critical development phases of plants on the irrigation areas. So, for the present it seems economical to plan irrigation systems with a capacity less than the maximum water demand of the plants. However, yield averages will have to be further increased. It happens even now that in dry years more water would be needed to maintain the yield level. All the indications show that, rather than becoming milder, the extreme character of the weather in Hungary is unfortunately breaking century-old records every year. Under these conditions, planning the irrigation system so that it is capable of satisfying the full water demand of the crop if need be, cannot be regarded as over-cautiousness. Unfortunately, the water resources are on y able to cover the maximum water requirements in relatively few places, but wherever conditions allow it, and it will not result in a reduction in the irrigation possibilities of other areas, irrigation should be planned according to the maximum water demand of the crop.

LŐRINCZ, J.: Irrigation systems cannot be planned according to the maximum water demands of the plants, partly because there is not sufficient water available to satisfy the requirements in the critical periods, and partly because it would be very expensive. The peaks must therefore be levelled out.

MIHÁLYFALVY, I.: Crops require a continuous water supply for their growth and development. Water deficiencies, particularly those occurring in the critical phases of development, cause considerable yield losses. As a consequence of the wide introduction of monocultures it is becoming increasingly difficult to supplement the water which is lacking in the critical periods of the plants. Irrigation should therefore be started before the critical period, so that by the time the irrigation of a given field is completed water will still be readily available in the part of the field which was irrigated first. Reliable experimental results are available concerning the water norms for field crops and the optimum date for irrigation. These values generally refer to a 75% probability that precipitation will occur.

The economic limits of tolerance to water deficiency (drought) may differ from the biological limits of tolerance. In some farms or for some crops, e.g. when irrigating original grasslands, it may be reasonable to set the economic limit of tolerance at a lower level, while with crops of high production value, e.g. vegetable crops, it is justifiable to carry out irrigation at such a rate that the minimum of biological tolerance is never reached. In other words, investments in water management and the capacity of the irrigation system should fully satisfy the water requirements of the crop. For economic reasons it is not generally expedient to cover the full water requirements of the plants during the critical periods.

NÉMETH, S.: It is not wise to design irrigation systems by automatically adjusting them to the water requirements of the plants in the critical period of development. In general, there is a limit in any case to how far this is feasible, since crop rotation means that the plants grown on the irrigation area do not have identical development rates and irrigation requirements.

On irrigation farms growing deep-rooted plants on soils with a favourable water regime, I think it possible, for economic reasons, considering the water retention of the soil, to plan irrigation facilities with a capacity less than the water requirement during the critical development period of the main crop.

However, for crops with shallow root systems, particularly for vegetables and crops intended for the canning industry, one of the basic criteria of an irrigation system is its ability to satisfy uninterruptedly the water requirements of the plants during the critical periods of development. This is an essential requirement if the irrigation system is to operate at high economic efficiency.

PÁSZTOR, K.: For economic reasons the irrigation systems should be planned with a capacity somewhat below the water requirements of plants in the critical period, since Hungary belongs to the zone where irrigation is conditional on precipitation, and a total of 630 mm precipitation would be required in order to exploit the given light and heat conditions. Where this is not ensured every year, the missing amount of water should be supplied by irrigation. In determining the amount of irrigation water to be applied, the climatic and microclimatic conditions of the area must be reckoned with, taking into consideration the ground-water level, the structure and salt content of the soil, the specific water economy of the crop, the water capacity and water retention of the top- and subsoil, the average amount of precipitation and its distribution over the growth season.

PETRASOVITS, I.: The fundamental question when planning the capacity of an irrigation system is: what is the irrigation water requirement of the given area?

This depends on factors which vary from year to year, such as the amount of precipitation, the temperature, the wind, etc. Factors such as soil properties show hardly any change. The crop structure (varieties, species and their ratio) and the applied technology are factors that may change relatively quickly.

Due to these major variables the irrigation water requirement can only be calculated with a certain degree of probability when making the technical plans. Consequently, the irrigation capacity should be adjusted to the water requirement in the critical periods of the crops, but with a probability value that will mean that, considering the technical investments, the operational costs, and the additional costs of irrigation for the expected surplus yield, irrigation will be economically efficient, and the whole system of irrigation farming will be profitable.

It is possible to achieve this aim, since irrigation increases the profit, lessens the risk or renders the production of special crops (vegetables, rice, etc.) possible, which, with proper management and favourable economic conditions, will yield further economic and political results both at farm and national economy level (increased exploitation of capacity, widening the range of products, export possibilities, etc.).

PLETSER, J.: In designing irrigation systems the water demands of the plants and the losses of water caused by drought must be taken into consideration. Evaporation is much more intensive during droughts than in rainy weather. Warm, plentiful sunshine combined with the dry weather also increases the transpiration of the plants. The amount of water supplied by irrigation must thus be more than the lack of precipitation. Irrigation is economical even when the irrigation system does not fulfill its monthly or yearly plan owing to a sufficient amount of precipitation, because in a period of drought the crop can only be saved if the capacity of the irrigation system is large enough.

POSGAY, E.: If field crop production were planned to cover maximum water deficiencies the investment needed would be enormous and a vast amount of water resources would be tied up. This is not realistic either in agriculture or in other fields of production, except in certain special cases.

POZSÁR, B.: On structureless sandy soils in the Great Hungarian Plain the maximum water requirements of the crops can be satisfied by irrigation, with large investments.

SHMILLIÁR, M.: The water content of the soil must be maintained at a certain level during the growth season. In the critical period of plant development, owing to the higher water consumption and an occasional shortage of precipitation, this means an increased water supply. If crop size is to increase this extra water supply must be ensured. In the future crop prices will cover the extra costs. The extra cost will be returned through reliable production and yield surpluses. Irrigation systems should therefore be so planned as to satisfy the maximum water requirement.

SOMOS, A.: The higher the efficiency of irrigation (e.g. for horticultural crops with a high production value) the more reasonable it is to satisfy or nearly satisfy the water demand in the critical period. In the opposite case an increase in the irrigated area seems to be more promising.

SZABÓ, L. GY.: Irrigation should be carried out in accordance with the nature of the plant, in the critical period of development (e.g. in soybean a humid atmosphere must definitely be ensured during flowering to attain maximum fertilization). The equipment must be designed and operated accordingly.

SZALÓKI, S.: In planning the irrigation capacity the water requirement of the plants is only one of the factors which must be considered.

In field crop production it would not be reasonable to adjust the irrigation capacity to the maximum water consumption of the plants even if there were no rainfall at all during the year.

This is because soils are capable of retaining a certain amount of water, thus allowing there to be a difference between the dynamics of the water supply (rainfall and irrigation) during the vegetation period and the dynamics of water consumption.

Thus, if irrigation is organized in such a way that a large proportion of the water reserves in the soil are used up by the plants during the peak period of water consumption, then the water supply required to satisfy the maximum water demand of the plants will be much lower; the deeper the plants are rooted and the greater the useful water capacity of the soil, the lower the amount of irrigation water required.

Naturally, for crops with shallow roots or a high production value there are critical periods from the point of view of the water or moisture requirements. This must be taken into consideration with such crops and the irrigation plants must be prepared accordingly.

Some field crops (e.g. rough fodder plants, root crops, etc.) have no such definite critical biological periods, or alternatively, this period may occur any time during the growth season, whenever the water regime of the soil and the plants becomes permanently unfavourable.

In Hungary such conditions occur most frequently in July, because it is then that the water consumption (ET) is the highest, and by that time the water reserves in the soil are mostly exhausted if no irrigation takes place.

Consequently, the water deficiency arising in this period is usually taken as the standard when planning irrigation capacity.

It should be noted that irrigation is designed to prevent constantly unfavourable water regimes from arising rather than to cure them.

The irrigation capacity should thus be planned so as to make it possible to keep the water regime of the soil and the crop at a level suitable for production purposes throughout the year. However, this can only be achieved by taking into consideration at both planning and operational level not only the dynamics of the water demands of the given crops, but also the rooting depth and moisture requirements of the plants, the structure and level of production, the water regime throughout the entire soil profile, the characteristics of the ground-water, and the amount and distribution of precipitation.

A mathematical simulation model considered to be suitable for this purpose has already been elaborated and successfully tested.

In connection with the original question, I should like to add that irrigation has never been planned to satisfy the critical water demand, since the standard 0.57 lit/sec/ha hydromodule only permits a daily water supply of 3 mm, while in the critical period the water demand of the plant stand is about 5 mm a day.

In practice the problem is rather that the standardized parameters for the agronomical requirements, which serve as the basis for planning do not and cannot give us very much to go by when assessing the actual natural and farm conditions.

SZIKI, G.: In answering this question I must again use known facts as my starting point.

I should like to refer again to the "secret" of the success achieved in the production systems. The extent and rate of yield increase which has never before been experienced is fundamentally due to the co-ordination of production factors ensured at optimum or near optimum level. It is quite obvious to those working in agriculture that water is one of the most important production factors. Thus, as I have mentioned previously, water, like the other production factors, must also be supplied at the optimum level. This is the purpose of irrigation; there can be no other reason for it. It follows, on the other hand, that all the facilities aimed at replacing the lack of water (not only the irrigation equipment but also the pumps, conduits and other structures) must be planned in such a way that they are able to cover the full water requirement of the crop in question.

If they are not capable of fulfilling this task, e.g. because they are too small, they are unsuitable and in that case, though the production price may be somewhat lower it is definitely not economically efficient. Anything that fails to serve its purpose is only seemingly cheap, but cannot, in any circumstances, be economical.

The argument could of course be taken further. It seems logical to assume that with "cheaper" equipment planned on a smaller scale the water requirements of the plants can be covered in all but the critical periods, and to some extent even then, so the "life-saving" task of irrigation is fulfilled in this case, too.

These arguments are, however, refuted by an economic aim of fundamental importance. Hungarian agriculture was quite rightly given the task of increasing yields substantially and continuously, and this cannot be achieved with the equipment described above. One of the basic conditions for improving the economic balance is yield reliability, which is most seriously threatened in the critical period; irrigation is designed to eliminate this risk or at least to reduce it to a minimum; the life-saving role is not sufficient for this.

As a "refutation" of the above it might be remarked: "but it is cheaper", and the aim is to increase yields and make production reliable economically, not at any price. This is another attractive, but easily refutable argument. Let me quote from the question: "Precipitation during the vegetation period (from 1st April to 30th September) ranges between 300 and 350 mm in most parts of Hungary, and in three out of four years only 250—300 mm can be reckoned with . . ."

I fully agree with the facts presented in the question, as they have been proved by experience and research, including my own results. It has also been repeatedly pointed out that if water is not supplied in sufficient quantities in the critical periods, a minimum 25—30% loss of yield must be reckoned with.

If the average useful lifetime of reasonably up-to-date mixed pipe-line sprinkling irrigation systems is estimated at only 20 years and in 15 of these years ("in 3 out of 4 years . . .") critical water deficiencies occur which cannot be fully supplemented, the loss of yield in 15 years, taking the irrigated yield average as 60 q/ha and calculating a 25% loss, will be

$$\frac{60 \cdot 25}{100} \cdot 15 = 225 \text{ q/ha.}$$

At the present buying price this works out at $225 \cdot 275 = 61{,}875$ Ft/ha, in other words, at more than the prime cost per ha of the equipment.

To sum up: Irrigation systems and the structures attached to them must be planned according to the water demand of the crop in the critical period.

TÓTH, M.: The capacity of irrigation systems should always be designed on the basis of a so-called standard water requirement. The standard water requirement must result in an economic optimum, which is below the biologically justifiable maximum (critical period) water requirement. The difference between the maximum and the economically optimum water requirement will be the smallest when crops are produced on highly fertile soils resulting in a high production value per unit area, when crops requiring irrigation at different periods are grown on areas which can be supplied with water from the same irrigation system, and when the irrigation system is operated at maximum capacity (continuous day and night operation) during the critical vegetation period of the given crop.

UJVÁROSI, M.: In my opinion irrigation systems should definitely be adjusted to the water demand in the critical periods of the crops. If we do otherwise, then owing to the unreliability of precipitation during part of the year (and according to the meteorological data during the larger part of the year) we automatically give up the possibility of obtaining maximum yields. The very fact that in the central part of the Great Plain the precipitation during the growth season in 3 out of 4 years does not even reach the lower limit of the average values shows how necessary an adequate additional water supply in the critical period is. Furthermore, if we consider that the precipitation during the vegetation period may be so distributed that what would be a sufficient amount of rain falls after the critical period and cannot thus be fully utilized, the question becomes still more urgent.

Nevertheless, it should be noted that in general the size of the yield, particularly in cereals, depends not only on the amount of precipitation during the growth season but also on the quantity of water retained in the soil. After rainy years when the water content of the soil is normal or high, even a small amount of precipitation during the vegetation period may result in large yields. Catastrophically bad yields occur when

Table 1

Effect of irrigation on the yield of the tomato variety K.42
Gödöllő, 1970–71

Year	1970			1971		
Precipitation, mm						
from flowering to first picking	167			146		
from first to last picking	90			41		
Treatment	Irrigation		Yield, t/ha	Irrigation		Yield, t/ha
	date	mm		date	mm	
Control	0		43.2	0		41.0
1st critical period	26th June	40	59.6	8th July	40	57.7
		80	56.5		80	58.4
2nd critical period	15th July	40	41.5	16th July	40	49.1
		80	47.7		80	48.1
On the basis of soil water content		2×40	58.8		5×40	52.9

Date of first picking: 3rd August 1970 and 22nd July 1971, respectively.

insufficient autumn and winter precipitation, after a drought in the summer of the previous year, is followed by very little rain during the vegetation period.

VARGA, GY.: Most vegetables have a short vegetation period. If these plants, and also species with longer vegetation periods, are to be successfully produced and if their water requirements are to be fulfilled, not the total amount of precipitation during the growth season but the precipitation conditions in certain phases of their development are the most important. A water deficiency even for a relatively short period may cause considerable yield losses in vegetable crops, which can be expressed in both the quantity and quality of the yield. The replacement of water in such short periods makes the irrigation economically efficient even in relatively rainy years.

The results of an experiment on tomatoes are a good example of this. As the table shows, in 1970 and 1971, for example, when the amount of precipitation between flowering and the first picking was nearly the same each year, irrigation on a single occasion at the end of June or the beginning of July at a rate of 40 mm resulted in a large yield surplus (Table 1). Irrigation applied at the same rate 8 or 20 days later in the middle of July was ineffective or half as effective, respectively. Similarly bad was the effect of a higher rate or regular irrigation. Thus, the date of irrigation had a greater influence on the effect and result of irrigation than the total amount of water supplied during the growth season.

As the result of cucumber irrigation the optimum course of water supply necessary to obtain large yields was determined in relation with the daily accumulated sum of mean temperatures. The total amount of precipitation and irrigation water during the growth season ensured the largest amount and the best quality of yield within the limits shown in Fig. 1. This type of water supply can be achieved with a varying number of irrigations, as mentioned earlier.

In order to satisfy the water requirements of plants in due time, irrigation systems should be planned according to the water requirements during the critical development periods of the plants. In fact, it is reasonable to make preparations for a regular water supply to the plants, since it is only in this way that the water demand arising in the critical period can be satisfied quickly, during a brief time. The costs

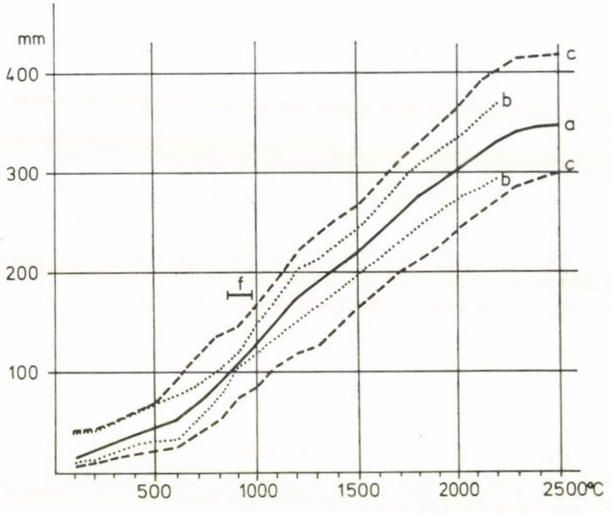


Fig. 1. Changes in the optimum water supply to cucumber as a function of mean temperature. Gödöllő, 1961—1971. *a)* Average, *b)* 25 and 75% frequency, *c)* extreme values, *d)* beginning of flowering. [In: VARGA, GY. (1972): A hőmérséklet, a víz és a termés összefüggései az uborkánál (Relations between temperature, water and yield in cucumber). Agrártud. Közl., **31**, 319—331]

can be reduced by growing plants with different vegetation periods, heat and water requirements, because in this way the critical periods of the plants occur successively, thus rendering the economical use of the irrigation system possible.

VÁNCSA, J.: The so-called critical period in the development of plants can also be determined with respect to the water supply. However, numerous components may be involved in the development of the critical period, and this creates conditions varying in space and time for irrigation technology. It must also be taken into account that the soil layer in which the root system is found is also one of the media of plant life. Every soil has a certain water retention capacity. Within the framework of irrigation farming it is possible to exploit this water capacity systematically, particularly where the groundwater level is low.

Taking all this into consideration, irrigation systems should be planned according to the water requirements of the crop production structure of the area in the critical period, when the extent of evapotranspiration is the highest and the probability of natural precipitation is the lowest.

*

PÁL, GY.: **Owing to the frequently occurring continental summers the main objective of plant breeding in Hungary has so far been to produce varieties with increased drought tolerance, giving satisfactory yields even in dry weather. Can the current commercial varieties only be grown successfully under dry conditions, or are they adaptable enough to be good yielders in irrigation farming as well, or again, does irrigation farming need varieties with higher transpiration coefficients?**

ALMÁSI, T.: The work of Hungarian breeders is well-known abroad. The ever wider range of varieties placed at the disposal of farmers in the last ten years is quite up-to-date. The potential productivity of the varieties used in commercial production is much higher than what is actually produced (e.g. maize, silo maize, winter wheat). Up-to-

-date varieties raise increasing demands on their environment (as regards water, nutrients, etc.). Farms which apply intensive irrigation must definitely have strong-stalked, resistant varieties which respond well to irrigation, while those which only carry out irrigation on a small proportion of their area are able to satisfy their demands from the existing choice of variety. Taking the long-term development of agriculture into consideration, it is desirable to increase the breeding and propagation of varieties which satisfy special irrigation requirements.

ANTAL, E.: In Hungary dry or droughty years are likely to alternate regularly with years when there is plenty of precipitation. It can therefore be expected that farms will continue to apply irrigation in one year and omit it in another in the future too. Owing to increased water utilization by industry water pollution will probably be more severe, and the amount of irrigation water suitable for use without cleaning will decrease. Parallel to this, the prices of energy carriers will rise and irrigation will consequently become more and more expensive. For climatic and economic reasons breeding should, in my opinion, continue efforts to produce plant varieties equally suitable for dry and irrigation farming. On the other hand, up-to-date evapotranspiration studies are aimed at using various chemicals to reduce the water consumption of the plant, i.e. to lower the transpiration coefficient.

ÁCS, A.: The plant varieties currently grown are already responsive to irrigation. The available water is often a limiting factor for the amount of yield they produce. It might be worth aiming at breeding varieties specially for irrigated conditions. If a variety has a genetically determined, faster rate of physiological processes, which involves increased water uptake and utilization, this will manifest itself in the amount of yield as well.

BALLA, L.: The plant varieties currently grown in Hungary are adapted to the ecological conditions, including the usual amount of natural precipitation and taking the possibility of dry and wet periods of 1—2 months' duration into consideration. Thus, they are not typically drought or humidity resistant varieties. Nor can it be said that "these varieties also give good yields under irrigated conditions". It is simply that in dry weather they give larger yields with supplementary irrigation than without it. It is common knowledge that in irrigation experiments in recent years the wheat yields were sometimes higher and sometimes lower than the non-irrigated control.

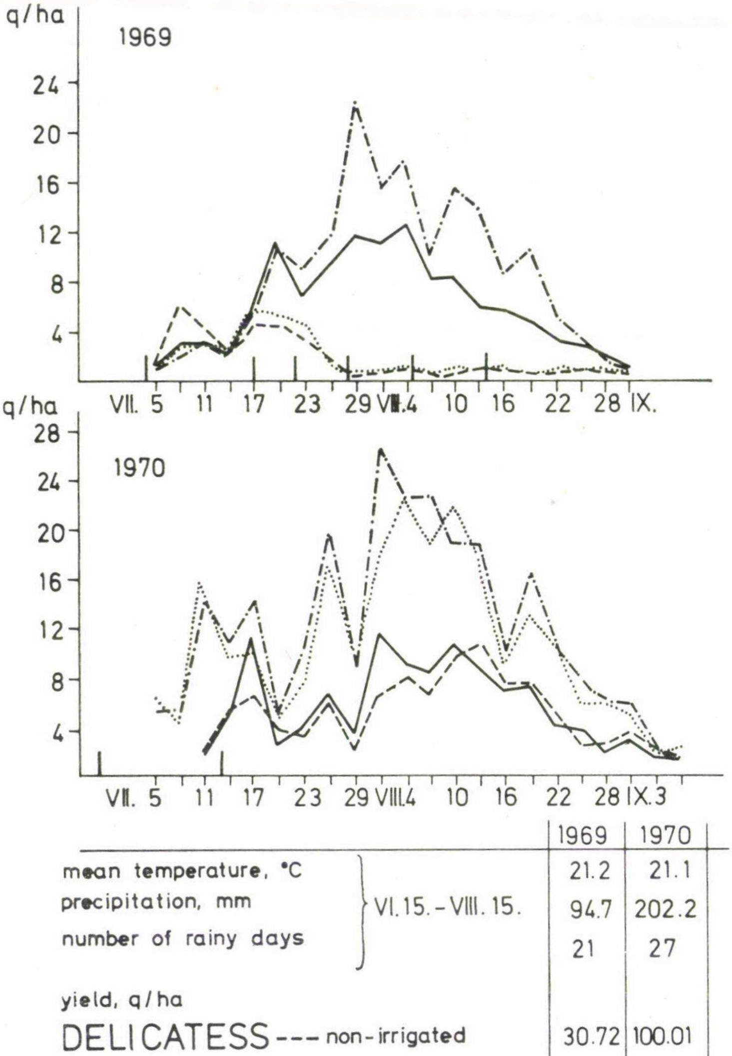
If wheat is to become an irrigated crop in the future, new types of varieties will have to be produced. Wheat varieties suitable for irrigation should possess the following properties:

- short stature with straw not longer than 65—70 cm (when irrigated),
- thick stalk, thin foliage,
- high individual productivity; minimum grain yield of 2.2—2.5 g/spike,
- hereditarily large thousand-grain-weight,
- excellent response to water and nutrient,
- excellent grain-straw ratio (harvest index) of approx. 1 : 1,
- outstanding disease resistance; under Hungarian conditions resistance to powdery mildew, stem and leaf rust and foot-disease (Ophiobolus, Cercosporella, Fusarium spp.),
- short vegetation period,
- steady quality.

If this wheat type is to be suitable for irrigation there must also be a physiological change compared to the present xerophyte type. It must also become adapted to the changed microclimate of the stand. This is manifested in the fact the irrigated wheat stand is thick because the plants produce a large number of tillers; solar radiation only reaches the flag-leaves, so the lower leaves turn yellow early, then wither and no longer take part in the process of assimilation. At the same time the biological yield also increases and the grain-straw ratio substantially changes, resulting in a larger grain yield.

The biological yield (without roots) of the present varieties amounts to 180—200 q/ha, of which 60—70 q is the grain yield. The biological yield of wheat bred for irrigation purposes is likely to be about 200—240 q/ha, of which 100—120 q would be the grain yield. This yield must be produced mostly by the flag-leaf, and to a lesser extent by the second leaf and the uppermost internode, so intensive physiological processes will take place in these parts of the plant and this may result in a higher transpiration coefficient.

It should be noted that on the basis of theoretical considerations some authors expect even larger yields, but so far not even this amount has been achieved under reproducible conditions.



		1969	1970
mean temperature, °C	VI.15.–VIII.15.	21.2	21.1
precipitation, mm	VI.15.–VIII.15.	94.7	202.2
number of rainy days	VI.15.–VIII.15.	21	27
yield, q/ha			
DELICATESS	--- non-irrigated	30.72	100.01
	—— regularly irrigated	115.19	111.09
HOKUS	······· non-irrigated	32.30	237.94
	–·–· regularly irrigated	167.53	265.23

| date of irrigation

Fig. 2. Effects of various levels of water supply on the dynamics of ripening in cucumber. Gödöllő, 1969–1970

BUDAVÁRI, K.: In Hungary many plants in commercial production are highly responsive to irrigation (a large proportion of hybrid maize, potato and sugar-beet varieties, and the alfalfa and sorghum varieties bred by the Irrigation Research Institue, Szarvas, etc.). More work must be done on these lines.

CSELŐTEI, L.: As the intensity of production increases varieties better adapted to the prevailing site and weather conditions should be produced rather than varieties with a higher tolerance to drought. Varieties more responsive to irrigation do not always

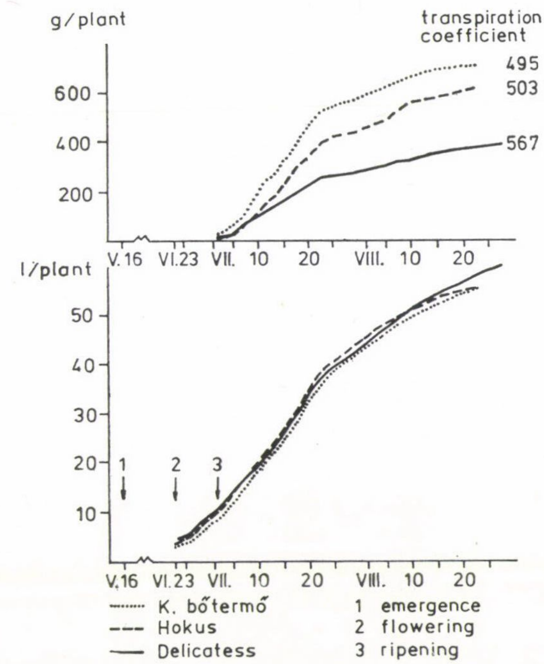


Fig. 3. Yield and water utilization in various cucumber varieties. Gödöllő, 1973

yield more without irrigation than the extensive varieties [CSELŐTEI, L.—CSIDER, L.—CSÁKY, A. (1978): Kertészet (Horticulture). University text-book. Mezőgazdasági Kiadó, Budapest, 655].

As an example I will present here the results of experiments carried out with two cucumber varieties in 1969 and 1970 (Fig. 2). The trend of temperature was largely the same in the two years, but there were differences in the amount of precipitation during the growth season. Consequently, in 1969 the crop results of the non-irrigated plots were similar. Under irrigated conditions the yield of Delicatess, the more extensive variety, was lower than that of the intensive variety Hokus. In 1970 when natural precipitation created equally favourable conditions for the irrigated and non-irrigated treatments of both varieties the variety Hokus gave considerably larger yields in both treatments than Delicatess. This suggests that the higher productivity of the intensive varieties usually only manifests itself under favourable conditions, in the present case as a response to a better water supply, otherwise their yields remain on the level of the extensive varieties or will be even lower.

With a favourable water supply, when the same amount of water is taken up, there may still be yield differences even between the intensive varieties, as is clearly shown by a pot experiment carried out in 1973 (Fig. 3), where not only did the extensive Delicatess give a different yield than the intensive varieties Hokus and K. high yielder, but there were differences in yield between the latter two varieties as well [CSELŐTEI, L. (1978b): Új irányok és feladatok a növények vízellátásában (New tendencies and tasks in the water supply of plants). (Academic inaugural lecture.) Agrártud. Közl., **37,** 45—57].

The transpiration coefficient is not directly related with the productivity of the plant; in fact, varieties excelling in this respect may have various disadvantages. From the point of view of production, varieties which yield more dry matter per unit amount of water under given conditions are preferred. It is also better if the utilizable plant parts represent a larger proportion of the total dry matter production than those which cannot be utilized (root, stalk, leaf, in cases where these are not valuable).

DEBRECZENI, B.: Breeding for responsiveness to irrigation should be aimed at increasing the productivity of transpiration, i.e. the amount of dry matter produced per litre of water discharged, rather than at raising the transpiration coefficient.

FRENYÓ, V.: Before the irrigation system of farming began to gain ground, Hungarian breeders tried to produce plant varieties tolerant to the continental summers of the country. The question now arises, whether these varieties give favourable responses to irrigation.

I think only practice can decide to what extent a plant species and its varieties are able to adapt themselves to changes in ecological factors, in the present case in the water supply. It is not the transpiration coefficient that ought to be increased, since this would act against the economic efficiency of production (the crop would use more water to produce comparatively less dry matter). It is the productivity of transpiration, that is, the reciprocal of the above parameter, that should be increased whatever method of cultivation is used. Its value ranges between 1 and 8; that is, when the plant takes up 1 litre of water from the soil, and transpires it into the atmosphere, this loss of water is followed, by means of photosynthesis, by a minimum 1 g and a maximum 8 g increase in the organic matter content.

The question could be put in the following way: is it not those varieties whch show more intensive transpiration that ought to be given preference in breeding? In this case the intensity of transpiration is stressed.

The intensity of transpiration is indicated by the amount of water released in unit time, referring mainly to the surface. In daytime, when the stomata are open and the heat also increases transpiration, its value is 15—250 g/hr/m^2. At night this value falls to one-tenth or so. In my opinion, however, this parameter too will only be of practical use as an index if the increased water consumption made possible through irrigation really increases the yield.

In connection with irrigation the science of plant physiology is faced with enormous tasks. The water demand of individual plant varieties in various phases of development must be determined. Reliable irrigation standards must be established for all cultivated plants and all development phases. It is only then that the crops can be rationally supplied. Apart from knowing the critical development phases a knowledge of the critical saturation deficiencies and a computation of the drought-induced stress may help in approaching efficient irrigation farming.

The critical saturation deficiency is the limit of water loss in the cells, beyond which damage irreparable even with irrigation occurs. The critical saturation deficiency is expressed as a percentage value of the total water content. For example, in the case of alfalfa leaf cells this value is about 70%, while in soybean it is around 41%.

The stress caused by drought can be calculated on the basis of these values, according to the relationship below:

$$\text{Stress} = \frac{\text{actual saturation deficiency}}{\text{critical saturation deficiency}} \times 100$$

For example, the critical saturation deficiency for flax is 65%, below this value the plant withers. If it has a water loss of 57.2%, for instance, compared to full saturation, the extent of stress is 88%.

In this way the response of any variety to drought and wetting can be followed fairly well. It is still true, however, that only practice renders it possible to find out to what extent drought resistant varieties can utilize irrigation water.

FÜRI, J.: Besides winter hardiness, drought resistance must be one of the main objectives of breeding. Unfortunately, in the case of grapes it takes a great deal of time to produce such a variety, so either currently available varieties reasonably tolerant to drought should be grown or the water deficiency should be made up for by irrigation.

GYENGE, J.: The irrigation area and the irrigation capacity are likely to increase, depending on the financial state of the national economy. In my modest estimation the bigger and "better" half of the area of Hungary will sooner or later be suitable for irrigation. And if this is so, well-planned breeding is badly needed for crops with high water requirements, the ones which will be irrigated, as the plants to be grown must also be able to adapt themselves to the intensive conditions imperatively necessary for irrigation.

In my opinion, breeding is necessary not only to increase the transpiration coefficient, but also for resistance and to overcome other phytopathological problems.

Thus, increasing the transpiration coefficient is just one — and not the most important — of the breeding aims, since irrigation also has an optimum (and here I am not thinking primarily of economic aspects), determined by the physical, biological, cultural, etc. properties of the soil to be irrigated. Among other reasons, this optimum must be found because the soil must be regenerated by the following season if it is to be suitable over a long period for the maintenance of a constantly high level of production.

HARMATI, I.: Irrigation farming will need new varieties, which, besides better disease resistance, straw strength, etc., will respond to irrigation with a higher yield surplus than those bred for the purposes of dry farming. In spite of their higher productivity, their transpiration coefficients should be lower, not higher, for economic reasons, if for nothing else. To produce larger yields they will naturally need more water. It should be noted that the new, higher yielding varieties have lower transpiration coefficients than earlier varieties, i.e. at a higher agrotechnical level they utilize natural precipitation better.

HORVÁTH, I.: I see some contradiction in the way the question is put. In connection with "varieties with increased drought tolerance it says in one place that they can only be grown successfully under dry farming conditions", and later that "they are adaptable enough to be good yielders in irrigation farming as well". If this is so (I am not aware of the details) these varieties need not be irrigated.

It is a generally known fact that varieties with higher transpiration coefficients give larger yields. It follows, in turn, that on areas where it is planned to introduce irrigation farming new varieties should be grown.

KISS, A. S.: Under irrigated conditions the variety is of even greater importance than otherwise. If proper use is to be made of the advantages of irrigation varieties which are potentially tolerant of irrigation are needed. The present varieties give different responses to irrigation; Libellula, for instance, has given a surplus yield of 3.4 q/ha, and Kavkaz 5.2 q/ha, while Avrora has yielded 8.6 q/ha more when irrigated. Similar differences have been found for maize; irrigation has resulted in a yield increase of 10 q/ha for Sze TC 255 and 26 q/ha for the maize variety TC 3505. In the case of alfalfa the sensitivity of the variety also manifests itself in that the crop begins to die off (to thin out). Szinalfa, for example, starts thinning out by the third year, while Szarvasi 2 is tolerant to irrigation. The above examples do not exclude the possibility of applying irrigation to the present varieties, but there is nevertheless a need to breed varieties specially for this purpose.

KOVÁCS, G.: Irrigation is an agrotechnical operation, but owing to its complex nature it raises questions concerning plant nutrition, soil science, etc.

Previously breeding in Hungary was adjusted to the ecological conditions of the country, and its objective was, accordingly, to produce drought resistant varieties. The changed fertility of the soil has made it possible to obtain larger yields with a lower amount of water. The question arises whether varieties responsive to irrigation are needed or ones responsive to intensive farming. The two run parallel to some extent, because intensive conditions postulate the presence of water. Irrigation brings about a different microclimate in the plant stand to that in intensive but non-irrigated systems of crop production.

Irrigation changes the biological conditions of the soil; some fungi and bacteria increase while others decrease in numbers. This can be illustrated using alfalfa as an example. Alfalfa is known to have drought tolerance, long life, etc. When alfalfa irrigation experiments were begun in the fifties it seemed that there were no special difficulties. Alfalfa responds to irrigation with large yields. But when three years lateral another irrigation experiment was set up with alfalfa on the same area it was found that from the third cutting in the second year onwards and also in the third year considerable thinning occurred in the stand owing to the lack of air in the soil, the multiplication of various Fusarium fungi, etc. Today, it is not only in irrigation farms that diseases cause great damage in alfalfa in rainy years. This is why alfalfa has become a "two-year" crop in many intensive farms. As a result of breeding, the alfalfa varieties Szarvasi 1 and Szarvasi 2 show good field persistence, tolerate frequent cutting, give a favourable response to irrigation and endure the lack of air in the soil caused by the use of large machines. Hence, large alfalfa yields cannot be obtained without resistant varieties and irrigation.

There are maize hybrids which give highly favourable responses to irrigation while under dry conditions their yields are not outstanding. The basic material for breeding alfalfa and maize must naturally be produced with regular irrigation. There are varieties, e.g. the large-leaved white clover Szarvasi 4, which cannot be grown reliably without irrigation. There can be no doubt that if any progress is to be made in irrigation (intensive production) by breeding plants responsive to these conditions the present research is not sufficient. Today everybody is convinced of the important role of breed in modern poultry farming or milk production. This shows that there are no breeds which are universally suitable for any purpose in livestock farming. In crop production, however, universal varieties are needed. The aim is to produce biological users which make special rather than average use of the ecological conditions. If further steps are to be taken in irrigation farming, as they must be, greater efforts must be made to create the biological bases.

LELLEY, J.: The possibilities of breeding for drought resistance were greatly limited in the past as the primary consideration was to increase the hereditary yield potential of the varieties by any means available, in order to make them competitive both at home and abroad. This breeding trend was discontinued in Hungary some fifteen years ago; earliness has remained the only character which helps to increase drought resistance. Some of the currently grown varieties give relatively good responses to irrigation, but none of them has been bred for irrigation farming. In this field there are many unexploited possibilities and much to be done. When breeding cereals, root-crops and rough fodder plants, which are the most suitable for irrigation farming, an increase in transpiration capacity is not the most important objective. Although the plants of high yielding varieties have to build more water-soluble nutrients into their organisms than low yielding, drought resistant varieties, which means that they have to transpire more water, it is not the varieties which consume the most water for the production of 1 kg dry matter that give the best results under irrigated conditions. The best varieties are those which utilize the available water resources with the highest degree of efficiency even under irrigated conditions. This is manifest in the lower value of the transpiration coefficient. The ideal varieties are the ones which utilize a balanced water supply most economically, rather than those which waste water while having a high transpiration coefficient. This applies equally to cereals, legumes and rought fodder plants.

LŐRINCZ, J.: If it is to give a more favourable response to irrigation the variety must have a lower rather than a higher transpiration coefficient. In fact, with a well-balanced water and nutrient supply any species or variety has a lower transpiration coefficient than under unfavourable conditions.

MIHÁLYFALVY, I.: Many Hungarian and foreign researchers are engaged in studies on the water requirements of various agricultural and horticultural plants, and concrete results are available in this field. These results and data throw light on the diversity of water requirements and utilization in different species and varieties. For example, it has been proved that more water is used to produce a unit of dry matter in open pollinating maize varieties than in hybrids. At the same time, in a stand the latter require more water because of the higher number of plants per unit area and the larger yield. In the case of species grown on larger irrigation areas, breeding should be extended to include the development of varieties highly responsive to irrigation. According to data acquired over many years of experimentation, higher productivity in a variety is coupled, even in the case of irrigation, with a reduced transpiration coefficient. In other words, increased yield intensity is associated with more economical water consumption and more favourable water utilization. A good example of this is the doubling of the maize yield under unchanged climatic conditions.

NÉMETH, S.: A highly important factor in the success of irrigation farming is the proper choice of variety. Some of the varieties currently grown give good yields even under irrigated conditions owing to their high adaptability. Parallel to the extension of the irrigation area in Hungary the breeding of new varieties responsive to irrigation was included in the research programme of certain research institutes, including the Irrigation Research Institute, Szarvas. The results have justified this step.

Instead of varieties with higher transpiration coefficients irrigation farming calls for ones which efficiently utilize the water, and which, with a favourable water and nutrient supply, produce larger amounts of organic matter suitable for human and animal nutrition. A higher transpiration coefficient does not mean increased productivity in the variety in question.

PÁSZTOR, K.: There is a need for plant varieties with higher transpiration coefficients, more responsive to irrigation. According to the experiments carried out so far there are significant differences between the plant species as regards the transpiration coefficient. Water deficiency has a great influence on the photosynthetic processes. Similar differences have been found between varieties, the genetic basis of which requires further investigation. It should be noted that varieties with higher transpiration coefficients have longer vegetation periods, which must be shortened by breeding because of the danger of frost (e.g. maize, vegetables, etc.).

PETRASOVITS, I.: Irrigation means interference with the water conditions of a given area. This interference, which is expensive and in the long run is often dangerous, can be agronomically successful if the crop structure and technology of the given area are capable of making good use of nearly optimum water conditions.

The central element of this intensive crop structure is more intensive biological material, i.e. plant varieties with higher productivity. However, higher productivity (genetic potential) does not always or necessarily mean higher values of transpiration coefficient.

The value of the transpiration coefficient seems to express a capacity for water uptake and discharge, which is a function of variety and ecological conditions, rather than the water utilization capacity or the genetic potential.

PLETSER, J.: Plant breeding must continue to concentrate on producing varieties which, while resistant to drought, are responsive to irrigation and show high adaptability. Varieties with high transpiration coefficients increase not only the yield but also the production costs.

POSGAY, E.: Plant breeding is aimed at producing varieties which fully satisfy both the qualitative and quantitative demands raised by production under the given or expected conditions. Specialization makes its effect felt in this respect too, so the production of varieties which make better use of the water supplied is both justified and possible. Raising the transpiration coefficients of these varieties cannot be the aim of breeding, nor is this likely to be achieved, since the transpiration coefficient generally decreases with an increase in yield.

POZSÁR, B.: An important precondition for yield reliability is to breed varieties with low transpiration coefficients and to introduce them into commercial production. Similar importance is attached to the production of plants of generative character (e.g. dwarf and semidwarf types), chiefly because of their higher capacity for organic matter accumulation. The utilization of a photoperiodically neutral basic stock in breeding high yielding varieties is also expected.

SHMILLIÁR, M.: It is true that drought resistant plants tolerate climatic extremes better, and these plants can also be grown under irrigated conditions. But in these varieties the yield cannot be increased to the level which is likely to be needed soon to meet new demands, and there is also some fear that the quality indices of the increased yield will not fulfil the requirements. In my opinion breeders should produce varieties with higher transpiration coefficients. Constant work is being carried out in the breeding institutions to produce a change of variety, and there have already been some results. Some varieties give large, high quality yields under changed conditions. The breeders must recognise changes in the requirements well in advance, because the production of a new plant variety may take decades and the public is impatient for its demands to be satisfied.

SOMOS, A.: Numerous examples show that the so-called intensive varieties are more responsive to irrigation than the old drought resistant varieties. "Adaptability", like disease resistance, is seldom a general feature. The transpiration coefficient expresses the efficiency of irrigation, but it does not determine it, at least not alone, since it is highly dependent on ecological factors and is thus not constant even for the same variety.

SZABÓ, B.: Owing to the meteorological conditions, the main objective of plant breeding in Hungary has always been to produce plant varieties not only tolerant to the continental climate but also able to give satisfactory yields.

Fundamentally this view has not changed, nor need it be changed, since the irrigation areas are insignificant in size compared to the arable area of the country. It would be reasonable, however, to supply areas which possess highly fertile soils and up-to-date equipment with plant varieties able to make full use of these production conditions.

A recent problem encountered in many farms is that conditions have changed in this respect; the crops are not threatened now by a shortage of precipitation or occasional droughts, but the variety grown is not able to give an adequate yield response to irrigation.

Attention must thus be given to these areas in the plant breeding policy and new varieties must be produced to ensure that this highly important government investment will be quickly returned.

SZABÓ, L. GY.: The value of the transpiration coefficient fluctuates considerably; besides the ecological effects it dpends on the nutrient supply and the agrotechnics. Plant varieties with relatively low, constant transpiration coefficients are required, which regularly produce more organic matter with less water every year. In my opinion such varieties are more responsive to irrigation, but yield well even if irrigation is prevented.

SZALÓKI, S.: For the purposes of irrigation farming high yielding varieties responsive to intensive production conditions have to be produced. The main characteristics of these varieties are: tolerance to increased stand density, lower light requirement, better utilization of solar energy, strong straw and disease resistance. These properties are also important in dry farming, but they play a decisive role under irrigated conditions. At the same time, drought resistance is a less important character.

Higher productivity, on the other hand, provided the conditions are favourable, involves an automatic decrease in the transpiration coefficient in spite of the increased water demand.

Hence, breeding should definitely not be aimed at raising the transpiration coefficient.

TÓTH, M.: At a high level of production, when farming is well organized, I think that in plant breeding favourable crop years rather than those with extremely unfavourable precipitation conditions should generally be taken as the standard (for drought tolerance). At the same time, particularly with the crops which are grown on the largest area, there must be a range of varieties to choose from in regions with different precipitation conditions and water supply. Thus, in my opinion, instead of breeding varieties specially for irrigation a range of varieties is needed to suit different water supply conditions.

UJVÁROSI, M.: I think it would be a mistake to expect the water conditions over a large area to change so much in the near future that the present drought tolerant varieties could be replaced by varieties which require more water. The character of the Hungarian climate remains unchanged and so do the extremes it is capable of. Considering that the available water resources are restricted, the irrigation systems very expensive, and the investment possibilities limited, it seems reasonable to continue to grow varieties suited to Hungary's climatic conditions, in the meantime eliminating yield fluctuations due to the extreme weather conditions and steadily achieving the maximum possible yields on the largest possible area. This does not necessitate the development of varieties with higher transpiration coefficients; in fact this would be disadvantageous as it would mean that a regular, higher rate of irrigation would be required. There are great differences in adaptability between the varieties; this question must not be treated too rigorously, but it would be better to stick to continental varieties.

VARGA, GY.: When studying the water metabolism and the efficiency of irrigation in cucumber, tomato and bean significant differences were found between the varieties. With the old, traditional cucumber variety Delicatess 3.0—11.3 ton/ha yield was obtained, depending on the weather conditions of the different years, without irrigation. With regular irrigation the yield ranged from 7.5 to 14.2 ton/ha. The yield of Hokus, a variety with substantially higher productivity, was also 3.3 ton/ha without irrigation under unfavourable conditions, but in a good year as much as 25.3 ton/ha could be obtained without irrigation. With regular irrigation the annual yield ranged between 12.6 and 29.1 ton/ha, depending mainly on the temperature.

In field trials and pot experiments the old, traditional varieties and the new, higher yielding varieties and hybrids (e.g. cucumber varieties with female flowers) showed similar yield differences when nearly identical amounts of water were supplied. The higher yielding varieties were better able to utilize the more favourable water supply ensured by irrigation. When these varieties were grown in pots, lower rather than higher transpiration coefficients were obtained. In cucumber the transpiration coefficient was 368—567 for the variety Delicatess and 332—503 for Hokus between 1967 and 1975. The dry weights of the two varieties were almost identical over the average of the experimental years, ranging from 60 to 200 g a year. The leaf/fruit ratio was more favourable in the variety Hokus, thus resulting in more efficient transpiration. The variety Hokus required 12—68 g less water to produce 1 g dry matter.

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PÁL, GY.: **Different crops have different leaf areas; e.g. a stand of maize with normal density has a leaf area of 2.7 m^2 compared to the 85.6 m^2 leaf surface of alfalfa per 1 m^2 sowing area. The loss of irrigation water is equal to the amount of water evaporating from the surface of the soil and the plant, plus the immediate atmospheric evaporation of the irrigation water, all of which depend on the humidity of the air. Should the leaf surface per unit area and the method of soil cultivation be taken into consideration when determining the amount of irrigation water to be applied?**

ALMÁSI, T.: Farms which carry out methodical irrigation must use the information supplied by water balance equations as their starting point in making decisions. The extent of evaporation, run-off and infiltration greatly varies with the method and technique of irrigation. From the point of view of the plant grower, yield can only be obtained by the amount of water taken up and utilised by the plant. The fact that today irrigation water is available almost unrestrictedly results in wasteful management and an economically unfounded point of view. Should a rapid decrease in the water resources take place or some of the national economic costs of irrigation be charged to the grower, the latter would definitely be forced to economize on the irrigation water. The improvement in the technical level of irrigation systems, rational soil cultivation and economical irrigation are all possibilities for increasing efficiency.

According to the results of investigations on night irrigation in automated systems, the loss due to evaporation can be reduced by 20—40%. Under the present conditions there is very little that can be done to reduce losses due to different soil properties.

ANTAL, E.: According to the results of agrometeorological investigations in Hungary the loss due to evaporation occurring in the course of sprinkling irrigation (from the soil surface, plants and drops of irrigation water) is not more than the amount of water which corresponds to the energy value of the radiation balance measured in the plant stand. Under the climatic conditions in Hungary the radiation balance of field crops in the summer months ranges from 200 to 350 gcal/cm^2 a day on average. Expressed as water this means 3.3—6.0 mm/day. Thus, with continuous sprinling irrigation the loss of irrigation water through evaporation is about 6 mm on a day (24 hours) with average weather conditions. If the green mass is small, when the interception of the plant may be less than 1 mm, the loss will naturally be within the limit values given above. Consequently, if the amount of water supplied during the day is less than 25—30 mm, the size of the leaf surface must be taken into consideration, because the loss is then as much as 15—20% of the 25—30 mm. At a higher rate of irrigation the leaf area need not, in my opinion, be taken into account, as the loss is less than the error with which the irrigation water can be measured.

Ács, A.: There is undoubtedly a correlation between leaf area and transpiration, but this varies with the species and the variety. Special attention should be paid to this in determining the amount of irrigation water, and the method of soil cultivation must also be taken into consideration.

Budavári, K.: Different plant species have different water and soil cultivation demands. This water demand includes the size of the leaf area and the method of soil cultivation too. However, the irrigation norms should be established on the basis of measurements carried out at evapotranspiration stations rather than by theoretical calculations. For this reason at least 1 evapotranspiration station should be set up for each soil type (sandy soil, light, medium and heavy loam) in each climatic region (a minimum of 4 in Hungary) where the major plant varieties of the respective areas should be included in the examinations.

Cselőtei, L.: The amount of irrigation water depends on many factors besides the size of the leaf surface. It is influenced by the depth of the root system, the water content of the different soil layers, the size and development stage (age) of the plant, its ecological requirements, etc.

In the course of our irrigation experiments we have found no direct relationship between the size of the leaf surface and the amount of water used by the plant. The senescing plant uses less and less water although the leaf surface still increases for some time [Cselőtei, L. (1965): Az öntözés rendszerének tényezői a zöldségnövényeknél (Factors in irrigation systems for vegetable crops). Academy doctor's thesis. Manuscript, 332; Cselőtei, L.—Varga, Gy. (1973): Az uborka fejlődésének és vízfelhasználásának összefüggései (Relationships between the development and water uptake of cucumber). ATE Mg. Karának Közleményei, 139—149], as shown by an earlier experiment (Fig. 4). Besides the late June-early July peak of water uptake the figure clearly shows that the leaf surface increased until the end of July and the weight of the leaves increased until the beginning of August. The process of senescing from the second half of July onwards is also indicated by the decreasing amount of fruit at each successive picking. This occurs even with a favourable water supply. Without irrigation the productivity of the plant was reduced to a minimum by the second half of July.

Frenyó, V.: The question is, whether the leaf surface per unit area should be taken into account when determining the amount of irrigation water, considering that there are differences in this respect between the plant species, e.g. between maize and alfalfa.

The answer is perhaps simpler than the question. As a very general statement, a plant with a larger leaf area/m^2 will undoubtedly transpire more water. However, it is hardly worth listing the possible variations in the geometry of the leaf which may modify the transpiration values. For example, a lanceolate leaf shows a higher intensity of transpiration than a round, shield-shaped leaf with the same surface area, insofar as all other conditions are identical. It is not worth delving into these questions, as those engaged in irrigation are only interested in the water requirement and consumption of the crop in question. The following data may be of relevance here. According to Risler the daily water consumption of 1 ha of pasture in summer is 31—73 m^3 (which corresponds to a 3.1—7.3 mm water cover); at the same time 1 ha potato consumes 7—18 m^3 water (equivalent to a water layer of 0.7—1.8 mm). The two kinds of plant stand have uniform growth areas, whereas the total leaf area is much larger in the case of the pasture; accordingly, together with other factors, the vegetation of the pasture consumes more than four times as much water as the potato field. From a practical point of view, however, it makes no difference whatsoever what kind of evaporating surface caused the fourfold water consumption.

Fibre flax consumes 276—292 litres/m^2 water during the growth season, compared to a water consumption of 265—310 litres/m^2 by soybeans. The two crops have largely the same water consumption, although they are highly different in morphology. On the other hand, there is a considerable difference in the amount of dry matter produced, which is 0.4—0.6 kg/m^2 in fibre flax and 0.3—0.4 kg/m^2, that is, some 30% less, in soybeans. It is obvious that under the given conditions the organic matter production of flax was better than that of soybeans.

All this naturally depends greatly on the extent to which the crops are supplied with nutrients. In this respect the data of O. Hank and M. Frank are instructive. They state that the dry matter production of a nutrient-deficient clover stand is 22 q/ha, while its water consumption is 4383 m^3. Well-fertilized clover, on the other hand,

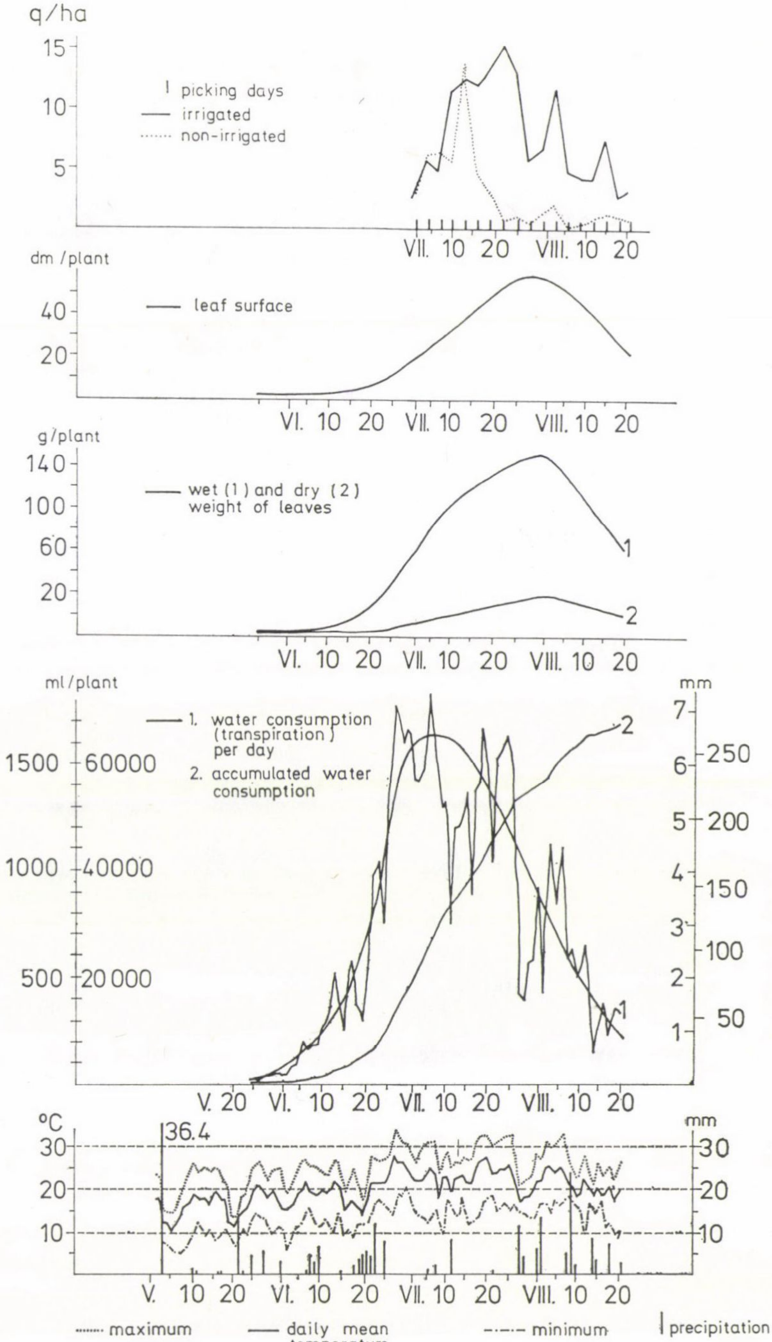

Fig. 4. **Water uptake, growth and trend of yield in cucumber. Variety: Delicatess, Gödöllő, 1963**

consumes only slightly more water (4794 m^3) but yields 94 q/ha dry matter. The yield, is more than fourfold, while the water consumption is only about one-tenth more. In the case of fodder beet the corresponding figures are as follows: in the case of deficient fertilization the dry matter production is 90 q/ha (with 2553 m^3 water), while an adequate nutrient supply results in 167 q/ha dry matter (with 3580 m^3 water). Hence the production is nearly doubled while the water consumption is less than one and a half times as much.

All this shows that it is not the size of the evaporating surface which is the essence of the problem. The true basis of production is the light utilization of the plants. Experience shows that good light utilization is generally ensured by a leaf surface three times the area of the plant stand. That is, in a closed stand 3 m^2 leaf surface per 1 m^2 soil surface promises to be favourable. So in practice the productivity of photosynthesis has priority over transpiration.

FÜRI, J.: When determining the amount of irrigation water both the water transpired through 1 m^2 leaf surface and that evaporated from the soil, which depends on the method of soil sultivation, must be taken into account. Both can of course be influenced: transpiration by potassium fertilization, for example, or by applying antitranspirants (Folicote, etc.), and evaporation by reduced soil cultivation — minimum or non-tillage, or by planting grasses.

GYENGE, J.: In determining the amount of irrigation water to be supplied both factors must be taken into consideration for the following reasons.

1. Crops are irrigated in different phenophases. At first sight it seems easy, for example, to determine the irrigation water requirement for the two plants mentioned in the question, and owing to the large leaf surface per unit area, and the consequent high loss of transpiration, alfalfa appears to require large amounts of irrigation water. However, in the case of alfalfa stubble irrigation is employed, when the transpiring leaf surface is negligible, because the closed mature stand must not be irrigated.

- The stand lodges, becomes tangled, and on harvesting serious damage occurs due to treading.
- It follows that the stand will be harvested with great difficulty and severe harvesting losses.
- It would anyway be pointless, inexpedient, and from the point of view of farm management definitely harmful.

Maize is irrigated somewhere near the tasselling phenophase, so it is natural for the loss through transpiration to be greater, and considerably so, in this crop because of the size of the leaf surface.

2. The method of soil cultivation also plays a role, although when examining this factor many other questions related with the water conditions of the soil must also be considered. In my opinion, to stick to the former example, the situation is reversed.

Assuming that deep cultivation is carried out well at the agrotechnically optimum time, the loss of water due to evaporation will be greater when irrigating a stubble-field of alfalfa, since the upper soil layer, packed by treading when harvesting the previous growth, does not readily absorb the irrigation water; in fact, evaporating water surfaces may be formed depending on the method and intensity of irrigation.

With a closed maize stand, on the other hand, the water absorption capacity of the soil is probably higher, especially if soil preparation and sowing were carried out when the soil was in an agrotechnically good condition. And a closed stand of maize also reduces the evaporation of irrigation water which has fallen onto the soil.

HARMATI, I.: There is a positive correlation between the leaf area index and the water requirement of plants, and this must be taken into consideration in determining the seasonal rate of irrigation. This is one reason why the water requirement of alfalfa, for example, is higher than that of maize, though the latter also rises with an increase in plant number.

In the case of sprinkling irrigation the method of soil cultivation usually only influences the amount of water to be applied at one time and the intensity of application, owing to the differences in water absorption between the soils.

The loss of irrigation water becomes greater with the increase in soil and leaf surface, but in my opinion this loss cannot be more than a few millimetres, which can be ignored during planning.

HORVÁTH, I.: To begin with, one, but maybe both of the two numerical data presented in the question are incorrect. In maize the 2.7 m^2 leaf surface (the leaf surface is twice the leaf area) per m^2 area seems to be small, while the value of 85.6 m^2/m^2 area given for the leaf surface of alfalfa is, in my opinion, too large.

As to the second part of the question, I think that in determining the right amount of irrigation water the leaf surface per unit area and the method of soil cultivation should also be taken into consideration. I might add that the leaf surface only needs to be considered if it is too small or too large compared to the morphological character of the plant.

No mention was made in the question of the soil structure, though I think this factor is at least as important as the method of soil cultivation.

LELLEY, J.: When determining the amount of water to be used per unit area the size of the leaf surface of the plants must be taken into consideration. However, water loss through transpiration does not only depend on the leaf area. Therefore, when determining the amount of water several other factors, which need not be listed, must also be taken into account, some of which are at least as important as the size of the leaf surface.

LŐRINCZ, J.: Werner's data concerning the leaf areas of plants are very old and are not reliable; they do not refer to current Hungarian species and varieties. This is also shown by the fact that the leaf areas given by Petrasovits for sugar-beet and maize, for example, are several times larger than those established by Werner at least fifty years ago. In fact, in determining the amount of irrigation water the specific leaf area and the method of soil cultivation are not taken into consideration. More irrigation water than the soil can usefully store should not be supplied.

MIHÁLYFALVY, I.: The water consumption of a plant stand is equal to the total water discharge (evapotranspiration) of the plant and the soil. Consequently, by increasing the biological potential of the variety and by raising the level of agrotechnics the water balance of the plant stand can be considerably improved and a larger yield can be obtained using a unit amount of water.

The water requirement of the plant varies with the phase of development. At the beginning, when the cotyledons and the first foliage leaves appear, the water requirement of the plant is low. Later, parallel with the growth of the leaf surface, the water consumption increases, then from the beginning of the generative phase onwards it gradually decreases. When suitable agrotechnical methods are applied water discharge through evaporation gradually lessens with the increase in the leaf surface. In trials performed with field crops the water consumption of the plants increased until the leaf surface reached 2—3 m^2. After this it remained unchanged, then in the generative phase, parallel to the senescence of the leaves, it gradually decreased.

NÉMETH, S.: In our experiments the leaf area of maize grown under irrigated conditions was 2.6—4.7 ha/ha depending on the variety. The leaf area undoubtedly influences the irrigation water requirement, but does not determine it.

In calculating the actual amount of irrigation water it is definitely wise to take the leaf area of the given crop into consideration.

The method of soil cultivation raises demands on the intensity of irrigation rather than on the amount of irrigation water.

PÁSZTOR, K.: In determining the amount of irrigation water the size of the leaf surface per unit area and the method of soil cultivation must definitely be taken into consideration. The leaf is the primary organ of transpiration, though transpiration takes place in shoots covered by young epidermis, and in flowers and fruits as well.

From the point of view of water economy, water retention and the critical point of water loss in the plant are highly important factors. The structure and biological condition of the soil can be favourably influenced by soil cultivation. It is a well-known fact that soils with a granular texture provide larger amounts of capillary water than those with a powdery or compact structure.

PETRASOVITS, I.: The size of the leaf surface (the value of the so-called leaf index) is an important bioecological parameter. Up to a certain limit the active leaf surface per

1 m² ground area shows a close correlation with both the yield and the total amount of water evaporating from the surfaces of plant and soil (evapotranspiration).

L_i	Sugar-beet potato, tobacco	Maize	Alfalfa ley
0.1	0.8	0.70	0.85
0.5	0.90	0.85	0.90
1.0	0.95	0.95	1.00
2.0	1.03	1.02	1.07
4.0	1.03	1.08	1.11
8.0	1.20	1.15	1.15
16.0	—	—	1.20

In the Petrasovits formula applied in calculating the extent of evaporation, $ET = k \cdot r \cdot t$, where the "k" factor is a value depending on the change in the leaf index during vegetation.

k = a biotechnical factor, the resultant of the actions of agrotechnical and ecological factors (variety, stand density, growth, nutrient, etc.),
t = daily mean temperature,
r = ratio of actual to possible number of sunshine hours as %.

At the beginning, up to a certain limit only, the leaf index is nearly parallel with the extent of evapotranspiration, while later it decreases specifically. Above a certain calue the leaf index has no practical effect on the total amount of water lost through evapotranspiration.

At low leaf index values (1—2) the method of soil cultivation may have a direct effect on the loss due to evaporation. The number of open cavities in the soil, and in particular the proportion of small to large pores, are important regulators of evaporation. An increase in the number of these open microsurfaces in the soil leads to more intensive evaporation, especially in the case of low leaf index values. The shading effect of larger leaf surfaces, on the other hand, checks evaporation from pores and cavity surfaces.

The 85.6 m² leaf surface mentioned in the question must be an extreme case for alfalfa; in irrigated alfalfa stands immediately before the first cutting we have never obtained leaf index values higher than 20.

In irrigated maize, on the other hand, the maximum leaf index value obtained at the time of flowering has often been as high as 4, or even higher — depending on the variety and the technology.

PLETSER, J.: When determining the necessary amount of irrigation water, in addition to the size of the leaf surface per unit area, the water demand at the given phenophase must also be taken into consideration. Soil cultivation is generally suspended during the vegetation period, as the weeds are controlled with chemicals. The atmospheric loss of water can be reduced by spacing the plants more closely, because in a denser stand the air temperature is lower, the humidity is higher and there is less wind. In necessarily thinner stands, e.g. vineyards and orchards, the atmospheric loss of water can be reduced by sprinkler irrigation. Thus, in determining the amount of irrigation water the stand and the method of irrigation must be taken into account.

POSGAY, E.: In my opinion, neither the leaf area nor the method of soil cultivation need be taken into consideration in practice when determining the loss of irrigation water, since some of the water on the leaf enters the plant through the leaf itself, while the rest evaporates from the surface, thus reducing the transpiration of the plant; in short, neither this nor the type of soil cultivation have any essential influence on the loss of water.

Since the evaporating surface has considerable influence on transpiration, the surface of the plant definitely has some connection with the water demand (e.g. development stage).

POZSÁR, B.: The transpiration coefficient expresses the transpiration relative to the surface of the plant. This must be taken into consideration when determining the rate of irrigation.

SOMOS, A.: The question itself makes it clear that the water loss due to irrigation cannot be directly related to the size of the leaf surface, otherwise the water requirement for alfalfa would be 32 times higher than for maize. Many authors suggest that the extent to which the soil is covered by vegetation has a more immediate effect on the water demand. In fact, the transpiration coefficient, the circumstances which modify it and the length of the vegetation period exercise a more direct influence on the need for irrigation.

SZABÓ, L. GY.: When determining the amount of irrigation water, stand density and leaf area must be taken into consideration, since these determine the relative humidity characteristic of the microclimate of the stand.

SZALÓKI, S.: The difference in water requirement between the plant species is mostly due to variations in leaf area and vegetation period.

The size of the leaf surface varies not only with the species; within the species and varieties it is considerably influenced by the stand density and other agrotechnical and ecological factors. Investigations show that within each species there is a logarithmic relationship between the leaf area and the transpiration of the plant stand, and that this is particularly significant when the leaf area index is less than 2 m^2.

Apart from the size of the leaf surface the total water demand is also influenced by the life-period of the foliage, the length of the vegetation period, and the age and condition of the leaves.

These factors should therefore also be taken into consideration when determining the irrigation water requirements, the more so because the size of the leaf surface is usually in close positive correlation with the yield, especially in the case of rough fodder crops.

However, a higher yield level normally needs more irrigation water. It is now possible to take these factors into account too, when determining the irrigation water requirement.

The method of soil cultivation directly influences evaporation, the absorption and storage of precipitation, and the amount of run-off water, and indirectly, through its effect on the development of the plant stand, the extent of transpiration.

Nevertheless, I do not think it is either necessary or possible to take this into account, as the soil cultivation methods employed in Hungary do not essentially differ as regards their effect on the water regime of the soil.

TÓTH, M.: Water consumption may vary considerably according to the plant species and the method of cultivation (stand density, length of vegetation period, etc.). With irrigation, too, great differences in water loss (sometimes as much as 40—50%) may occur according to the time and method of irrigation. Thus, the amount of irrigation water has to be determined with all the important production factors taken into consideration as well as the conditions of irrigation.

UJVÁROSI, M.: Every cultivated plant species has a genetically determined water requirement for the production of 1 kg dry matter. The size of this requirement is most closely correlated with the size of the leaf surface — or more correctly of the transpiratory surface. In most cases this requirement varies even within a species and is characteristic of the variety. Naturally, when plants with different water requirements are grown this fact must be kept in view. Since the water requirement can best be determined from the size of the transpiration surface, the latter must naturally be taken into consideration. And since the method of soil cultivation may have a decisive influence on the water regime of the soil, it is obvious that this cannot be ignored either in planning the irrigation system.

VARGA, GY.: The results of spacing (stand density) experiments set up with the same plant species and variety in the field testify that changes in the moisture content of the soil are substantially influenced by the size of leaf surface per unit area. The same correlation was observed in a given plant stand during the growth season, and with different stand densities at a given time.

*

PÁL, GY. **The transpiration coefficient, which expresses in litres the amount of water required for the plant to produce 1 kg dry matter, is 349 for maize, 433 for sugar-beet, 575 for potato, 634 for rye, 783 for flax and 844 for alfalfa; for barley it is 349 in sunshine, 483 in intensive dispersed, 519 in medium dispersed and 676 in poor dispersed light. In your opinion does this transpiration coefficient express the genetically determined water demand of the plant or its adaptation to an environment with a given or varying water regime?**

ALMÁSI, T.: The value of the transpiration coefficient is primarily determined by the plant species. However, the variety and the cultivation conditions produce a considerable extent of deviation from this value. Reference should be made to the fact proved in practice that a plant stand harmoniously supplied with nutrients is able to produce a record yield after a period of drought. The soil cultivation method used over the last ten years in Hungarian farms, whereby the soil is loosened to some depth without turning, seems to support this theory.

ANTAL, E.: My colleagues and I spent many years carrying out experiments with various field crops using a Thornthwaite evapotranspirometer with an area of 4 m^2. The nutrient and water supplies were identical and optimum every year. The transpiration coefficient of MV-1 hybrid maize varied from year to year to a considerable extent (between 150 and 600 litres) in spite of the unchanged treatment. On average it ranged from 300 to 400 litres. Similar results were obtained with 5 other plant species, though the average values were different (data close to the values given in the question were obtained for potato, sugar-beet, alfalfa). According to our investigations the yearly fluctuation of the transpiration coefficient was decisively influenced by those meteorological factors which act on the photosynthesis, even if the water supply was optimum. According to the relevant international literature the value of the transpiration coefficient varies with the climatic zone as well. On the basis of the above it can be said that the average value of the transpiration coefficient (under the climatic conditions of Hungary about 350 mm for maize, 575 mm for potato, 800 mm for alfalfa) is jointly determined by the climate and the genetic properties of the plant, while its variance depends on the weather during the vegetation period and on the adaptation of the plant to the ecological factors (not only to the water supply).

BUDAVÁRI, K.: The value of the transpiration coefficient varies considerably with variety and conditions (nutrient level, water supply, air temperature, etc.), and only the averages are characteristic of the individual varieties. That is

- the agerage values show the genetically determined water demands of the varieties,
- the deviation from the average (the "width" of the band) indicates the adaptability of the variety.

CSELŐTEI, L.: The transpiration coefficient, which expresses the ratio of the accumulated dry matter to the amount of water utilized, is a physiological parameter. The results obtained by other authors as well as our own experiments show that it is characteristic of the species and the variety. Its value is not, however, constant and it develops depending on ecological factors, particularly on the weather, which may cause it to change considerably. The transpiration coefficient shows the relationship between the water uptake and the accumulated dry matter in its final result and not as the two characteristics develop, so it has hardly any practical importance (with respect to the periodical water requirements) and cannot be put to much use in practical plant cultivation. As regards the utilization of the total amount of water applied, the problem is represented by the fact that the quality of the accumulated dry matter and its incorporation into the fruit must also be taken into consideration [CSELŐTEI, L. (1959): A hőmérséklet hatása a zöldségnövények vízforgalmára (Effect of temperature on water turnover in vegetable plants). Növénytermelés, **4,** 333–348].

In support of this I should like to present the results of some experiments. Parallel to the long-term tomato experiment mentioned previously the water utilization and productivity of the same variety was examined when raised in pots. In these experiments the transpiration coefficient was also determined and was found to be 281 over an average of 14 years, ranging from 225 to 335 in the different years. It is clear from this experiment, where the data obtained in the individual years are listed according to the amount of water consumed by the plants, that there is no direct relation between the transpiration coefficient, the water utilization of the plant and the amount of dry matter accumulated in any given year (Fig. 5A). For the sake of interes, the bestresults of the non-irrigated and irrigated treatments given in Table 1 aret shown in Fig. 5B. The yield, like the total dry matter production of the plant, is not

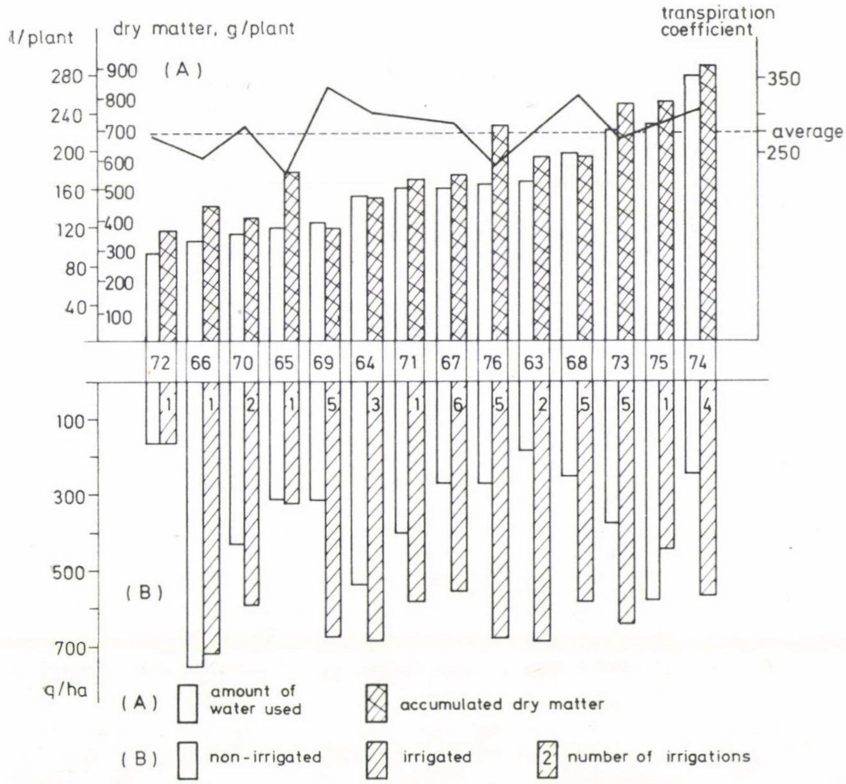

Fig. 5. Water turnover and yield in tomato. Variety: K.42, Gödöllő, 1963—1976

directly related to the number of times irrigation is carried out or to the parameters of the simultaneous pot experiments. This is quite natural, as the yield is greatly influenced by other factors (e.g. the time and circumstances of fruit setting, etc.).

The transpiration coefficient varies with the specier [CSELŐTEI, L. (1964): A zöldségnövények vízhasznosítása (Water utilization by vegetable plants). ATE Mg. Karának Közleményei, 203—226]. The way it changes in different years is similar but by no means identical (Fig. 6). In general it is lower in cooler, rainier years and higher in warmer, drier years. Since the quantity of the accumulated dry matter is particularly influenced by the size of the yield, and since the time and conditions needed for yield development differ from plant to plant, the differences are considerable, despite the more or less similar tendency.

The effect of the weather is demonstrated even better in a long-term fractional sowing experiment using the same bean variety, where the transpiration coefficients were established (Table 2). In the same development phase, i.e. in the same growth periods of the different years, the transpiration coefficents show highly varying values. The highest value is more than one and a half times larger than the lowest one. When all the phases of each year are taken into consideration the difference between the highest and lowest value only reached 40% once. The difference between the averages of the different phases is even smaller. In this case the transpiration coefficient is lower in the first and last phases, when the temperature in the larger part of the vegetation period is lower. On the other hand, the transpiration coefficients of plants grown in mid-summer are higher. It is interesting that in the latter case the higher transpiration coefficient is occasionally coupled with more dry matter and a larger yield (Table 3). This suggests that under such conditions, with an optimum water supply, the requirements of the plants are better satisfied in Hungary.

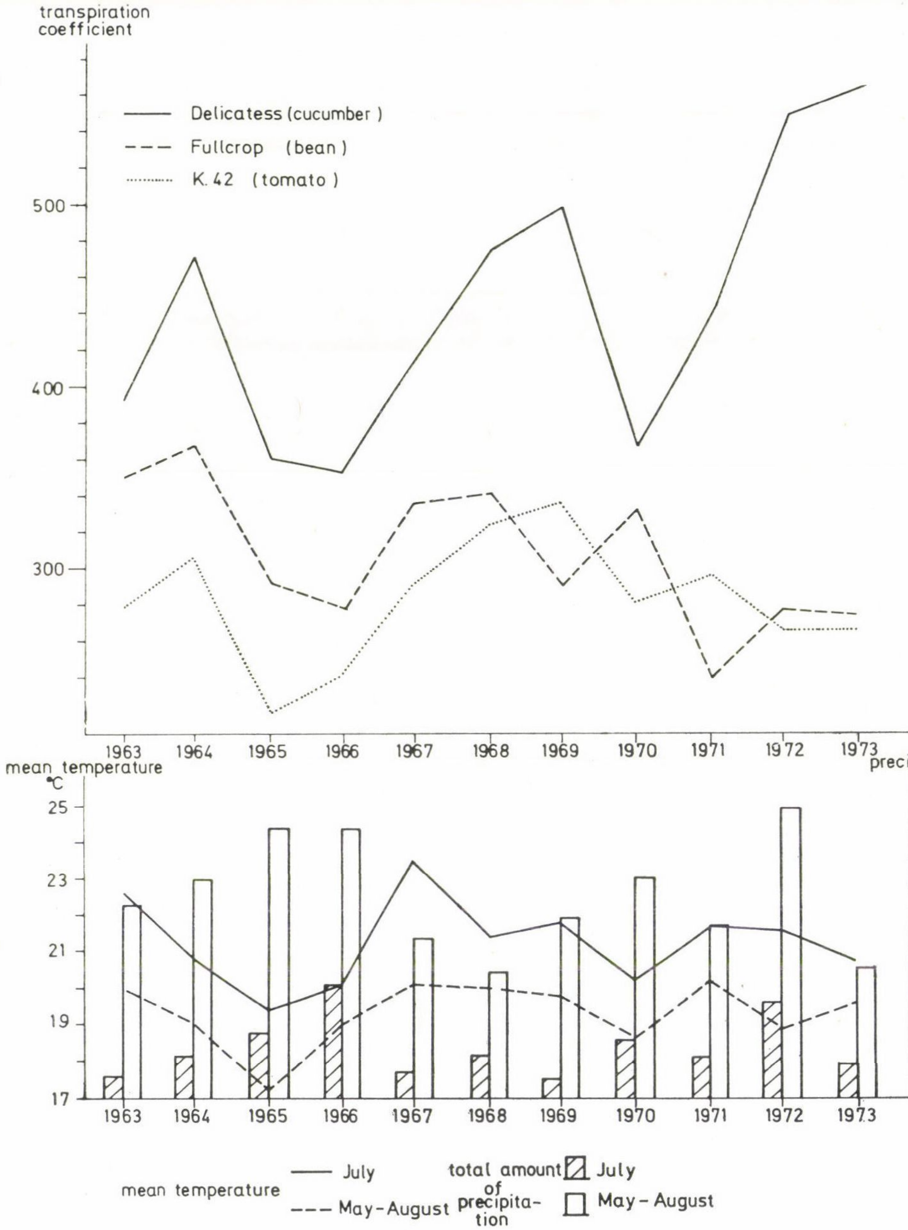

Fig. 6. Yearly changes in transpiration coefficients. Gödöllő, 1963—1973

Table 2

Transpiration coefficients of bean
Variety: Fullcrop
Gödöllő

Growth season month*	Phase	1963	1964	1965	1966	1967	1968
May/1—July/1	1.	350	369	235	285	336	342
May/2—July/2	2.	343	391	275	251	323	371
June/1—July/3	3.	375	404	260	322	356	372
June/2—August/1	4.	410	413	270	277	393	337
June/3—August/2	5.	408	381	247	277	397	318
July/1—September/1	6.	266	287	260	258	402	353
July/2—3—September/2—3	7.	—	282	269	257	317	—
	Average	359	361	259	275	361	349

Growth season month*	Phase	1969	1970	1971	1972	1973	1963—73 mean
May/1—July/1	1.	290	334	240	279	277	303
May/2—July/2	2.	318	329	300	356	259	320
June/1—July/3	3.	319	312	310	296	334	332
June/2—August/1	4.	401	357	387	299	330	352
June/3—August/2	5.	413	351	410	317	436	360
July/1—September/1	6.	360	311	389	328	439	332
July/2—3—September/2—3	7.	320	319	—	230	418	302
	Average	346	330	339	301	356	328

* Numbers indicate 1st, 2nd and 3rd third of the month.

DEBRECZENI, B.: During its growth and development the plant becomes adapted to the environmental factors that influence its transpiration. One of the characteristic indexes of water metabolism in plants is the dynamics of transpiration in the vegetation period the total amount of water discharged and the amount of water used to produce a unit quantity of dry matter, which varies with both the climatic and the soil conditions (soil type, water content and nutrient level in the soil). Our own experiments may be used as an example: although plants treated with nitrogen or with fertilizers containing nitrogen in addition to other components discharge considerably more water than the control crops fertilized with phosphorus (or phosphorus and potassium), it is utilized much more economically, as is shown by the lower transpiration coefficient or higher transpiration productivity; the transpiration coefficient decreased by 20—50% in winter wheat and oats, and by 50—100% in maize.

FRENYÓ, V.: The transpiration coefficient is likely to be genetically determined to some extent. In comparison with clover, fodder beet shows much lower fluctuations in transpiration coefficient with the rate of nutrient supply. This is probably a genetic feature. At the same time, it may be an indication of the different adaptability of the plants: the less the transpiration coefficient varies with the conditions, the more adaptable the variety is, because the metabolism is less influenced by the changes. This question would be worth examining more closely at some other time.

Table 3

Characteristics of beans sown at different times
Variety: Fullcrop
Gödöllő, 1969

Phase	Sowing	Emer-gence	Flower-ing	Commer-cial ripening	Transpira-tion coefficient	Stem + leaf	Fruit	Total	Stem + leaf	Fruit
						weight			air-dry weight	
						g/plant				
I.	6th May	15th May	18th June	4th July	290	52.59	36.08	88.67	9.33	2.98
II.	17th May	27th May	26th June	11th July	318	46.59	28.29	74.88	7.89	2.19
III.	30th May	7th June	8th July	23rd July	319	55.30	43.18	98.48	10.02	3.25
IV.	13th June	19th June	23rd July	4th Aug.	401	53.61	52.48	106.09	10.32	4.36
V.	27th June	6th July	4th Aug.	17th Aug.	413	60.75	37.18	97.93	9.89	2.88
VI.	11th July	19th July	17th Aug.	5th Sept.	360	63.34	33.02	96.36	9.99	2.66
VII.	25th July	1st Aug.	13th Sept.	26th Sept.	320	48.36	25.23	73.59	10.03	2.16

Füri, J.: The coefficient of evapotranspiration, including transpiration, varies greatly over the average of several years for different vine varieties. E.g.:

Variety	ET coeff.	T coeff.
	l/kg	
Afuz Ali	148	81
Gloria Hungariae	164	85
Olimpia	276	148
Pannonia Kincse	106	56
Szőlőskertek Királynéja	197	97
Average	178	93

It follows that the water consumption of the vine varieties is genetically determined, though it is naturally influenced by the ecological (dry or humid) conditions.

Gyenge, J.: In my opinion the transpiration coefficient expresses not only the genetically determined water requirement of a species or variety but also its adaptability.

To support this view mention may be made of the results of various variety trials, which show that with the same amount of precipitation the varieties give different yields. To the best of my knowledge the special irrigation water requirements of the varieties included in the trials have not been studied even at the Irrigation Research Institute. However, investigations aimed at determining the potential productivity of a variety should be extended to include the examination of this factor.

The variety descriptions, particularly those of maize, give the number of plants/ha under dry and irrigated conditions, although in an arid climate the plants may not receive as much water even with irrigation as those grown under dry farming conditions on an area with a normal climate. It would be wiser to be more circumspect in making classifications. Attempts are already made to formulate in some way or other the nutrient requirement, so why should this not be done for the irrigation water requirement?

This leads to the question of whether a true picture of the transpiration coefficient of a variety can be obtained without knowing the amount of water required if the potential productivity is to be manifested. (I am not thinking here of laboratory determinations.)

To give an indication of adaptation ability I should like to mention the dynamically increasing wheat yield averages obtained in recent years. With possible help from other agrotechnical operations (foliar plant protection, cultural level of top soils, variety, etc.) and a varying supply of precipitation, different amounts of water were required to produce a unit quantity of product (Tables 1 and 2). The adaptation of spring barley to the light conditions can be mentioned as a further example.

Harmati, I.: Owing to changing conditions in the field, the transpiration coefficients of plants range between very wide limits and are affected more by factors acting on the yield (edaphic, climatic and agrotechnical factors) than by the genetically determined water requirement of the plant. This is clearly demonstrated by the values of transpiration coefficients calculated from the average yield of 3 maize hybrids.

Year	Total water consumption, mm	Transpiration coefficients* on soils with a		
		bad	medium	good
		water regime		
1974	362	965	505	428
1975	421	598	499	470
1976	255	1409	450	317

* Amount of water in litres required to produce 1 kg grain yield with a 14% mois-ture content.

Effects of fertilization and irrigation on the transpiration coefficients of the wheat variety GK 3, averaged for 1976 and 1977

NPK, kg/ha	Non-irrigated		Irrigated	
	l/kg	D	l/kg	D
Ø	538		662	
110	500	38	586	76
220	456	82	514	148
330	416	122	466	196
440	401	137	488	174
550	397	141	489	173
Average	451		534	
ET value:	347 mm		407 mm	

The water requirements of plants are considerably influenced by the extent of the nutrient supply. On soils well supplied with nutrients the plants need less water to produce 1 kg dry matter. This is why a sudden increase in the yield averages of wheat, maize, etc. has become possible under practically the same precipitation conditions through a higher rate of fertilization. This is also proved by the following experimental data.

The transpiration coefficient of the plant is thus a value which varies even within the variety, since the yields and water requirements of the varieties are considerably influenced by the given environmental factors.

HORVÁTH, I.: From the listed values of the transpiration coefficient the latter seems to be in no immediate relation with the dry matter production of the plant. For the yield, on the other hand, it is of basic importance. It follows, in turn, that the transpiration coefficient is genetically determined, so the necessary amount of irrigation water is influenced by the plant species grown. The question is not, however, as simple as that, since plant species, e.g. those listed in the question, obviously have different water absorption capacities (osmoctic pressures).

I do not wish to argue with the transpiration coefficients given for barley under different light conditions, nevertheless, the actual light conditions and the temperature and relative humidity of the air should at least be known if they are to be interpreted properly.

Considering that the light conditions in the field during the whole of part of the vegetation period do not normally differ very much, attention should chiefly be paid to the specific characters rather than to the transpiration coefficient, which is influenced by ecological factors.

KISS, A. S.: On studying the transpiration coefficients of plants they are found to show considerable differences depending on the species and the experimental conditions. In maize the value of the coefficient is 340 in dry air and only 191 in humid air. In the case of alfalfa it has been found to depend on the useful water content of the soil; for example, the transpiration coefficients obtained with 35 and 80% useful ground water gave a 45% difference in favour of the better water supply. Since transpiration is influenced by the extent to which the stomata are open, and the latter is a function of light intensity (assimilation), transpiration is also influenced by light intensity. Transpiration also varies with the stage of development; in oats, for example, it is much more intensive during shooting than at the time of green maturity. Species are well known to differ with regard to the intensity of transpiration. From the above it can be concluded that the value of the transpiration coefficient, although it is genetically determined, greatly depends on the environmental factors (water supply, air humidity, light intensity, etc.), as well as on the development stage of the plant. This proves the high adaptability of plants.

LELLEY, J.: The example mentioned clearly shows that there is no correlation between the transpiration coefficient and the size of the transpiring leaf surface. There are certain physiological reasons for this, that need not be listed here, and this demonstrates that the transpiration coefficient is rather an unreliable parameter. The correlation between the hereditary productivity and the transpiration coefficients of the varieties has not been correctly interpreted so far.

The hereditary yield potential is much too complex a character to be described with a single parameter. Nevertheless, the limit values of productivity are characteristic of the species, and to a lesser extent of the variety, and are also related with the water demand, which is also hereditary. Therefore, the variety has a higher water demand if its transpiration coefficient is higher, as it transpires more water while producing a unit quantity of dry matter. It must be emphasized, however, that this is not necessarily an advantage, even in varieties grown under irrigated conditions. Varieties which transpire more economically are definitely better.

LŐRINCZ, J.: The transpiration coefficient is not genetically determined, since various authors have found different values for the same plants. It is a well-known fact that under different conditions the same variety may have substantially different transpiration coefficients. With a favourable water and nutrient supply it may be considerably lower.

MIHÁLYFALVY, I.: The plant transpiration coefficient cannot be regarded as static as it varies with the species, or even the variety, and with the ecological conditions; nevertheless, under the same conditions it is characteristic of the species or variety. Foreign and Hungarian research results show that, of the climatic factors, the temperature, and of the agrotechnical factors, the nutrient supply (fertilization) have the greatest influence on the development of the transpiration coefficient. In the course of pot experiments carried out with field crops the most favourable (lowest) transpiration coefficient values were obtained when the water supply was adjusted to the current water requirements of the plants. If the water supply is deficient the utilization of water deteriorates, while with excessive irrigation the plants consume unnecessarily large amounts of water.

NÉMETH, S.: Transpiration coefficients are only of informative value. The transpiration values are known to range between very wide limits depending on species, variety, ecological conditions, etc. Fundamentally, the transpiration coefficient expresses the genetically determined water requirement of the plant, but its value is considerably influenced by the ecological conditions (water and nutrient supply, etc.).

PÁSZTOR, K.: The transpiration coefficient is a characteristic of the plant at a given time and in a given environment, and expresses the adaptability of the plant, which may be genetically determined. The value of the transpiration coefficient is influenced not only by the intensity of light but also by the humidity, motion and temperature of the air; maize, for example, transpires about 340 litres water to produce 1 kg dry matter when grown in dry air and only 190 litres in a humid atmosphere.

PETRASOVITS, I.: According to our studies and calculations, transpiration coefficient values cannot be directly used in determining the water requirements of plant stands or the irrigation water requirements. They may lead to particularly incorrect data when calculating the dynamic values (course) of irrigation.

The transpiration coefficient is the resultant, between very wide limits, of the joint action of the water uptake and discharge capacity of the given plant variety, on the one hand, and an infinite number of combinations of the soil-atmosphere-hydrological cycle factor, on the other.

PLETSER, J.: Although the transpiration coefficient is obviously influenced by genetic factors it also varies with the development phase and the weather conditions, and depends on the nutrient content of the soil. Transpiration is proportionate to the humidity and temperature of the air, to solar energy and to wind velocity. The daily, monthly and seasonal trends of transpiration develop accordingly. The increase in dry matter depends not only on the carbon dioxide assimilation, but also on the amount of nutrient taken up from the soil. The transpiration coefficient is thus fairly variable; it may be considerably modified by cultural practices, including irrigation. As an example Hank's investigations may be mentioned, where the transpiration coefficient fell from 599 to 333 in spring wheat, from 481 to 322 in summer barley, from 397 to 333 in maize and from 809 to 647 in pink potato as the nutrient supply increased. The economic efficiency of production requires a reduction in the transpiration coefficient. As far as possible, irrigation should be carried out in those parts of the day, generally in the morning and evening hours, when transpiration and evaporation are at their lowest. Spacing the plants more closely to moderate the extent to which the stand warms up also contributes to a reduction in transpiration, because the degree to which the air humidity is short of saturation and the solar radiation per unit leaf area will decrease and there will also be less air movement. Thus, the transpiration coefficient for the whole growth season depends mainly on the cultural practices applied, and the lower it is at a given yield level the higher the economic efficiency of production is.

POZSÁR, B.: The transpiration coefficient varies with the species and variety, so it is likely to be of a genetic nature, since the accumulation of dry matter is decisively influenced by the intensity of photorespiration.

SOMOS, A.: The transpiration coefficient, like many other hereditary features, may manifest itself in different ways under the influence of the varying environment. The variability is further increased by the fact that the transpiration coefficient is a function of many hereditary properties which do not necessarily change in the same direction under the influence of the environment.

As an example it is sufficient to mention just one correlation: plants are generally known to show great differences in salt tolerance. As the salt concentration increases in plants with different salt tolerance the water uptake will obviously develop differently. Since there are also great differences in light requirement between the plants, under various light conditions the plants do not change parallel with the transpiration coefficient, i.e. they do not follow the formula of barley. Thus, in my opinion the transpiration coefficient expresses the environment-dependent, genetically determined water requirement of the plant.

SZABÓ, L. GY.: Since adaptability also depends on the genotype, it is natural that the transpiration coefficient is characteristic of the adaptability of the crop or the variety.

SZALÓKI, S.: Although the quantitative growth of individual plants and plant stands is partly determined genetically, it is influenced most strongly by the conditions existing during the development of the plants. The same goes for the transpiration of plants and even more so for the evapotranspiration of the plant stand. And since the transpiration coefficient expresses the quantitative ratio of dry matter accumulation to transpiration, it is influenced even more strongly by the conditions.

I should like to mention a few examples. In experiments using several hundred lysimeters it was possible to study the effects of a number of factors.

An alfalfa stand, for example, used up 396 litres of water through evapotranspiration in the last 5 years to produce 1 kg hay dry matter, over the average of the 64 replications in the experiment. However, this average covers a wide variation (200—900) measured in various treatments, amount of growth and crop years.

In general, it was found that all those factors which promoted the accumulation of dry matter (adequate nutrient supply and stand density, high productivity in the variety, plant care and a good supply of water) decreased the values of the coefficients, i.e. they increased the efficiency of the water.

I do not agree with those who think that plants with a favourable (optimum) water supply waste water, while those scantily supplied with water make better use of it.

In our experiments the water was generally used more efficiently by plants in treatments well supplied with water. In the dry year of 1977, for example, the specific water consumption (ET coefficient) with an adequate nutrient supply showed the following trends in the non-irrigated control and in the treatment best supplied with water:

in maize:	596 and 492 l/kg grain dry matter,
in 2nd-year alfalfa:	356 and 331 l/kg dry matter,
in sugar-beet:	118 and 93 l/kg beet, respectively.

In the droughty year of 1976 the differences were still greater in favour of the adequate water supply.

On the other hand, crops given a larger amount of water than necessary cannot take it all up.

Obviously, if the water is not absorbed by the plants it cannot be made use of; in fact, it may cause a lack of aeration in the soil, which will hinder the life processes (even transpiration) and decrease the productivity not only of the water but of all the other production factors too.

To sum up, I am of the following opinion:

— the transpiration coefficient is, in part, genetically determined, since there may be substantial differences between species and varieties even under identically favourable conditions;

— with an increase in the productivity of the cultivated plants the characteristic value of the transpiration coefficient tends to decrease;

— the actual value of the transpiration coefficient is determined primarily by the cultivation conditions. Therefore, much greater differences may exist between the actual values within a species or variety than between the characteristic values of the different species;

— since this index is highly dependent on the conditions and does not change uniform with the yield average, it can only be used to determine the water requirement with great caution and a thorough knowledge of the conditions and correlations.

TÓTH, M.: The transpiration coefficient expresses in a complex way the genetic properties of the given plant species, the farming conditions, the adaptation to these conditions and the state of the water supply. Any modification which improves the transpiration coefficient is highly important, because the natural water resources are limited and irrigation is an expensive additional investment.

VARGA, GY.: In our experiments the transpiration coefficient not only varied with the species, but also changed substantially within the variety. For example, the transpiration coefficient of the cucumber variety Hokus ranged between 332 and 503 from one year to the next. The differences in water utilization and dry matter production, from which the transpiration coefficient is calculated, suggest that the coefficient expresses primarily the water utilization ability and at the same time the adaptation of the given plant. The genetically determined water requirement of the plant is also expressed in this value, of course, though this may be concealed by the varying environmental conditions of the different years.

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PÁL, GY.: **Irrigated maize consumes 5000 m^2/ha (500 mm) water, potatoes more than 7000 (700 mm), sugar-beet more than 6500 (650 mm), and alfalfa 8000 m^2/ha (800 mm) water in a single vegetation period. To what extent do you think the amount of precipitation, its distribution over the vegetation period, the nutrient supply of the soil, the standard of the cultivation method applied and the productivity of the plant variety grown influence the quantity of yield produced by the cultivated plants in Hungary today?**

ALMÁSI, T.: The correlation between precipitation and yield is hardly disputable. The data on the size of the correlation are, however, highly contradictory. The cultivation level, surface and ventilation of the soil have a decisive influence on the ratio of run-off to infiltrating water. When plants are grown without irrigation, only part of the latter is available. The frequency and intensity of precipitation, the development stage of the plant, the size and position of the root system, and the amount and ratio of nutrients are all factors that may lead tofvery different yields even if the total amount of precipitation is the same. This multifactorial formula is not likely to be defined in the near future even with the most up-to-date computer techniques.

ANTAL, E.: It is very difficult to answer this question. A separate analysis must be made for each plant species as to what percentage the weather, the production technology and the biological productivity of the variety contribute to the present yield level. According to our investigations on maize the best yield can be expected when the temperature is average or above average throughout the growth season, and the total amount of precipitation in June and July equals or exceeds 160 mm. In the southern part of the Great Plain over the last fifteen years such growth seasons occurred in 1965, 1969, 1970, 1972, 1973, 1974 and 1975, while in the period between 1901 and 1975 only 14 years of this type were found, 6 of which fell within the last ten years. It can thus be said that the weather in the last ten years has been favourable for attaining large yields; on the other hand, this period coincided with the introduction of intensive hybrids and up-to-date production technologies. This succession of climatically favourable years cannot, however, be expected to continue in the future, and very great efforts will have to be made in the field of technological development and high yielding varieties will have to be introduced if the yield level is to be maintained or increased.

It can be said that the value of the yield trend is determined by the climate, the farm technology and the productivity of the variety, while the annual fluctuations above and below the trend depend on the weather. The percentage distribution of these effects can only be determined by means of a very detailed analysis.

ÁCS, A.: In my opinion the influence of each factor separately cannot be determined exactly, as their effects are exercised jointly and also act on each other.

To obtain large or record yields, varieties with genetically determined high production potentials (including rapid physiological processes, disease resistance, etc.) are needed.

— Adaptation to external conditions. Ecological factors have a decisive influence: not only precipitation, but also temperature, light, wind, etc.

— I think the distribution of precipitation in time is very important from the point of view of phenological phases. In peas, for example, rainfall before flowering has a decisive effect on the yield.

— The nutrient supply may also be of decisive importance. An optimum nutrient level for example, improves the yield reliability even under unfavourable ecological conditions. The nutrient content of the soil increases the efficiency of the available water (whether it is precipitation or irrigation water).

The factors are effective due to their interaction rather than by themselves — this must be emphasized. Each factor must be provided at the optimum level. A shortage of precipitation can be made up for by means of irrigation.

BORKA, GY.: Each plant species has a different critical water saturation level. Soybean, for example, can lose much less water reversibly than alfalfa. Therefore, besides other important factors, this must also be taken into consideration.

BUDAVÁRI, K.: Since irrigation depends on many factors, in Hungary it is only economical if all the factors are coordinated and kept at the optimum level (under irrigated conditions the yield is not influenced by the amount of natural precipitation, as the latter can be supplemented at any time by irrigation).

CSELŐTEI, L.: In my opinion the water consumption values given for the plants mentioned in the question are too high. That given for potato, in particular, seems to be high even when the evaporation is added to the transpiration of the plant.

The yields of plants are influenced to a considerable, thought varying, extent by the amount of precipitation during the growth season, particularly during the vegetation period of the plant in question. The distribution of the precipitation over the growth season may occasionally be even more important. Proper soil cultivation and a sufficient level of nutrient in the soil may greatly reduce the effects of an unfavourable water supply, as shown by the yield data for Hungary, where, since the introduction of large-scale production, some crops (maize, alfalfa, wheat, etc.) have suffered less from drought than before. The first signs of this were observed in 1968 [CSELŐTEI, L. (1969): A növények vízellátásáról (Water supply to plants). Tudomány és Mezőgazdaság, **7/2**, 23–32].

FRENYÓ, V.: Precipitation utilization means the ratio of the amount of water actually used by the plants to the total amount of precipitation. Besides the amount of precipitation, cultural practices also influence the quantity of water utilizable for plant growing. With good cultural practices surface run-off and water loss through evaporation can be reduced. The distribution of precipitation naturally has a great influence on the utilization of water, and — as seen above — this is not very favourable, particularly on the Great Plain. The situation can be improved by a balanced nutrient supply, but a final solution can only be expected from properly applied irrigation.

FÜRI, J.: According to data obtained at Kecskemét, under the conditions prevalent on the Great Hungarian Plain, table grape varieties showed the following optimum mm values of evapotranspiration during the vegetation period (from bud bursting to leaf abscission) over an average of 6 years (1970—1975).

Variety	OET, total mm	OET, day	OET, mm/day
Afuz Ali	458	191	2.37
Gloria Hungariae	445	193	2.32
Olimpia	427	196	2.21
Pannonia kincse	398	196	2.04
Szőlőskertek Királynéja	393	198	1.99
Average	424	195	2.18

The grape yield depznds primarily on the productivity of the variety, then on the nutrient supply, the method of cultivation, and last but not least on a satisfactory water supply. The presence or absence of water, which is the most important nutritive element and solvent, exercises a decisive influence on the development of the plant and on the quantity and quality of fruit.

GYENGE, J.: The practical farmer cannot separate the individual effects of the factors determining high yields, but can only guess at them. The amount of precipitation, its distribution over the vegetation period, the nutrient content of the soil, the standard of the method of cultivation applied and the productivity of the plant variety grown all have such a decisive effect on the yield that the "reduced" action of any one of them results in an immediate decrease in yield.

If any of them is reduced to a minimum a considerable proportion of the yield-forming effect of the other factors is "wasted" on replacing the effect of the minimum factor. In my experience, with the higher standard of farm management and the improved organization of crop production in recent years the minimum factor has ceased to exercise such a reducing effect on the yield as it did earlier. In droughty years, for example, in consequence of improved soil cultivation, nutrient management and production discipline the yields are no longer as catastrophic as would have been expected on the basis of experience a number of years ago.

If all the factors are at the optimum level, the amount of precipitation is sufficient, and the distribution over the vegetation period is satisfactory both in quantity and in time, then all the conditions for outstandingly large yields are given; in this sense the amount and distribution of precipitation are of primary importance.

If the farmer leaves any of the factors out of consideration, or for some reason is unable to provide them, he must reckon with an immediate reduction in yield. In my opinion the most serious mistake, which is basically up to the farmer, as it is a matter of organization and production tools, is to ignore the method of soil cultivation, especially in the case of low-lying soils with poor fertility, bad physical properties and poor water conditions. On these areas besides rational land use a certain amount of excess capacity must also be ensured in order to maintain the soil cultivation level. This is the only way to remain competitive with more favourable areas.

HARMATI, I.: As I have mentioned previously, the average of natural precipitation over many years in Hungary does not satisfy the water requirements of most plants, partly because of the low quantity, and partly on account of the mostly unfavourable distribution. The situation is made still worse by the fact that only a certain proportion of the precipitation is utilized, depending on the highly diversified water conditions of Hungarian soils. Consequently, the precipitation conditions greatly influence the yield averages, depending on the water requirements of the plants and the water regime of the soil. Water deficiency substantially contributes to the fact that only 50—60% of the productivity of plants is utilized in Hungary today.

As higher yielding varieties are produced and introduced into commercial production in the future, water deficiency will further increase. Water is thus becoming more and more scarce, in spite of the fact that at the present higher agrotechnical level natural precipitation is utilized with increasing efficiency. Amelioration, as a means of promoting the better utilization of natural precipitation, and the artificial replacement of water, are assuming increasing importance. Under the present economic conditions in Hungary the close dependence of the yield average on the precipitation conditions causes serious problems. The farms are struggling to increase their incomes and to keep at a steady level.

The influence of precipitation on yield in the case of maize is clearly shown in the table below.

The precipitation conditions even at a high agrotechnical level have a very great influence on the yield, which depends on the water requirements not only of the species but also of the variety.

The national maize yield average was 50.2 q/ha in the rainy year of 1975 and 41.7 q/ha in the droughty year of 1976, which means a difference of more than 20% for the country as a whole.

Apart from some extreme cases the correlation between wheat yield and precipitation is less close. For example, under completely identical agrotechnical and soil conditions the yield averages of the wheat variety GK 3 showed the following trend in 1976, 1977 and 1978: 81.6, 84.2 and 78.0 q/ha.

Changes in the grain yields of maize hybrids under different precipitation conditions on a soil with an unfavourable water regime

Hybrid	1974	1975	1976	1975—1974	1975—1976
Sze TC 255	75.0	87.8	52.3	12.8	35.5
KSC 360	63.1	95.2	54.1	32.1	41.1
BCSK 66-25	81.0	100.3	65.3	19.3	35.0

Apart from water, nutrient is the other agrotechnical factor has a great influence on the quantity and quality of yield. The substantial improvement in the nutrient supply is one of the major reasons for the sudden increase in yield averages. The yield-increasing effect of fertilization depends on many factors: plant species and variety; available nutrient content of the soil; pre-crop; climatic and soil conditions; rate, time and method of nutrition, etc.

On the basis of our experiments some data are given here to show the effect of fertilization on the yields of wheat, maize and grasses.

Effect of fertilization on grain yield in wheat grown on a calcareous meadow soil with medium NPK supply, averaged for 1976 and 1977:

NPK, kg/ha	GK 3		Jubileinaya 50	
	q/ha	D	q/ha	D
0	62.6		58.7	
110	68.8	6.2	65.0	6.3
220	75.6	13.0	72.0	13.3
330	82.9	20.3	77.2	18.5
440	87.0	24.4	79.4	20.7
550	86.8	24.2	80.8	22.1
$LSD_{5\%}$		7.2		6.9

On soils rich in available NPK, reliable yield surpluses were only obtained after wheat as pre-crop.

In 1978 220 kg/ha NPK, given at a ratio of 1.5 : 1 : 1, proved optimum for the wheat variety GKF 2; it increased the yield from 56.0 to 71.0 q/ha (by 15.0 q/ha). For the wheat variety N. Rana 1, on the other hand, the optimum rate of NPK was 360 kg/ha, applied at a ratio of 2 : 1 : 1; the yield increased by 28.1 q/ha, from 49.3 to 77.4 q/ha. The varieties also show considerable differences in nutrient demand and fertilizer response.

In agrotechnical experiments with maize grain yield surpluses of 5—17 q/ha were obtained as a result of fertilization, depending on the available nutrient content of the soil.

In fertilization experiments carried out on various types of irrigated grasses the following hay yields and nutrient effects were obtained:

On alkali soil:

with natural grass: $N_{210}P_{60}$ gave a 52.7 q/ha yield increase (from 31.8 to 84.5 q/ha)
with planted grass: $N_{360}P_{120}$ gave a 64.4 q/ha yield increase (from 51.7 to 116.1 q/ha)

On calciferous meadow soil:

with natural grass: $N_{100}P_{60}$ gave a 54.7 q/ha yield increase (from 15.2 to 69.9 q/ha)
with planted grass: $N_{360}P_{120}$ gave a 107.7 q/ha yield increase (from 34.9 to 142.6 q/ha).

From the few data listed above it is clear that with an adequate rate of fertilization, which depends on several factors, the yields of Hungarian crops can be greatly increased. I cannot give exact figures for the effect of fertilization on a national scale, but I think that if fertilization were totally eliminated for a year the yields of field crops would be reduced by some 25—30%. On the other hand, if the currently applied volume of NPK were better utilized, a yield increase of about 5—10% could be achieved.

HORVÁTH, I.: The factors mentioned represent highly different things and the yield depends on all of them. I do not think the question can be put in the form of which of the listed factors (amount of precipitation, its distribution in time during the growth season, level of cultivation method applied, productivity of plant variety grown) is the most important.

KISS, A. S.: Under Hungarian conditions the yield is largely dependent on the amount and distribution of precipitation. In the Agárd State Farm, for example, the average maize yield between 1970 and 1974 (dry years) was 51 q/ha. In 1975 approx. 50 mm rain fell on two occasions in the critical period, resulting in an average yield of 76 q/ha. Neither the plant number nor the amount of fertilizer were increased that year, so the surplus yield was due exclusively to the precipitation.

As regards the nutrient supply I should like to mention that the occasional omission of phosphorus and potassium fertilization does not cause any significant yield reduction because the soils in Hungary are generally well supplied with these nutrients, but when nitrogen application is neglected there are serious consequences, because nitrogen accumulates in the soil to a lesser extent. The negative response given by the plants to the omission of nitrogen fertilization is explained by the fact that this nutrient has the greatest influence on their development. In wheat, for example, 1 kg nitrogen results in a 12 kg yield increase compared to the 5 kg increase caused by 1 kg phosphorus.

The importance of choosing the right variety is well known, because while Kavkaz, for instance, yields 48.3 q/ha Libellula only gives a 34.9 q/ha yield. It is not sufficient, however, to consider only the differences in potential yielding ability; attention should also be paid to other factors, such as frost resistance, disease resistance, length of vegetation period, etc.

With the present high rate of fertilization (300—400 kg active agent) the method of cultivation, e.g. deep ploughing, has little importance. Nevertheless, deep ploughing to at least 30 cm is required about every four years to restore the soil structure. Under the influence of a long period of irrigation the humus content of the ploughed soil layer decreases, while in the so-called dead layer accumulation occurs. Occasional deep ploughing also prevents the silting up caused by irrigation.

Summarizing the above it can be seen that the favourable or unfavourable nature of precipitation, nutrient supply and variety may influence the yield to 50—60%, or sometimes to an even greater extent.

KOVÁCS, G.: Agricultural crops consume different amounts of water during the vegetation period. Alfalfa, for example, requires 750—800 mm available water to produce a 100 q/ha yield. This figure also shows that the amount of precipitation determines the yield in relation with various factors. At the present development level of agriculture I consider the productivity of a variety to be of primary importance, since the amount of water used for the production of unit yield decreases if the nutrient supply is favourable, and with a nutrient supply of 350—400 kg/ha the cultivation method has not much influence on the yield either (on chernozem and meadow soils). The distribution of precipitation in time and the uniform supply or availability of water determine the yield and the process of fruit formation. Moreover, if in certain phases of plant development, e.g. from emergence to tasselling in maize, a lower amount of water is available but in the most critical periods (flowering, grain formation) the plants are satisfactorily supplied with water, i.e. with economical water utilization, but with a favourable water utilization, but with a favourable water supply in the important periods, large yields can be obtained. Among the yield-forming factors variety is, in my opinion, the one that can be most economically and at the same time most rapidly produced and altered. If the future varieties have lower fertilizer conversion and more favourable water utilization larger yields will be obtained. As to the question of to what extent the yield depends on the amount of precipitation and its distribution in the growth season I am of the opinion that variety is the most decisive factor followed by the level of nutrient and water supply as almost equally important factors, while the method of cultivation is the last in order of succession.

LELLEY, J.: Under identical growing conditions the yield depends chiefly on the hereditary productivity of the variety, so in this case variety is definitely the dominant factor. Since the "identical conditions" may be very varied, the same variety will not have the advantage at all sites. The priority of the hereditary productivity of the variety must thus be understood with this reservation. All the experiments I know of prove that the second place in the order of succession, again if the other factors are identical, is taken by the meteorological conditions, and of these it is the amount and distribution of precipitation that primarily determines the yield. Taking the other factors as identical again, the nutrient supply is placed third, while the method of soil cultivation is the last in the order of succession.

LŐRINCZ, J.: Since the transpiration coefficient may vary to a considerable extent, the value of the specific water consumption determined for a plant is also variable. The yield undoubtedly depends on the factors listed in the question, but it is not easy to tell to what extent each of them influences it.

MIHÁLYFALVI, I.: My observations so far show that the distribution rather than the amount of precipitation during the vegetation period, the water balance of the soil and the agrotechnical conditions have a decisive influence on the yield trend. The type and extent of response given by the plant to a temporary water deficiency varies in the different periods of development. From the point of view of crop production it is therefore particularly important to know which are the periods when a permanent water deficiency will induce irreversible processes in the plant. The yield-decreasing effect of water deficiency occurring in the so-called critical period cannot be completely nullified by subsequent favourable weather or by agrotechnical intervention. Annual herbaceous plants are extremely sensitive to water deficiencies, especially at the beginning of the generative phase. This is why irrigation carried out during that period is of particular importance. The yield-forming role of the water supply becomes dominant when the other factors (variety, climate, agrotechnics) are at an optimum.

NÉMETH, S.: According to our experimental data, the yield trends of cultivated plants are greatly influenced by the amount of natural precipitation, and also by its distribution in the growth season. The leffect of irrigation, over the average of several years was moderate for plants with deep root-systems, giving a yield surplus of 40—45% in maize, 35—40% in sugar-beet and 30—35% in alfalfa, but higher for crops with shallow roots (100—120% in bean and 200—250% in green paprika). In dry years the effect of irrigation may be two or three times as great as the figures given above.

The nutrient supply of the soil, the level of cultivation and the productivity of the plant variety have a complex effect on the yield. Information as to the extent of the effect exercised by the factors that determine the yield trend is given in a relevant work by Dr. B. Győrffy and Dr. I. Oroszlány.

PÁSZTOR, K.: The answer might be formulated by saying that precipitation is the factor more or less responsible for large yields. But it is also worth considering what factor the yield achieved depends on if the nutrient supply and the cultivation method are optimum and a high yielding variety is used. I touched on this earlier when I referred to the values of the different factors (heat, sunshine, water) in Hungary. The investigations made so far have revealed that water is the minimum factor in Hungary. Large yields are therefore determined in some years by the amount of precipitation. However, it is not only the amount of precipitation during the vegetation period, but also the useful soil water content available to the plants at the beginning of the growth season that determines the yield in a given year. It was observed that in dry seasons following rainy years the yield did not decrease because the water stored in the soil replaced the missing precipitation.

PETRASOVITS, I.: The yield is the "outcome" of a biological and ecological system, the result of action and process.

The subsystems of this system are:

1. The variety-specific biological and practical productivity of the plant species grown;

2. The ecological demand of the plant species grown, which is bound up with the biological and actual productivity of the given variety;

3. The capacity of the natural resources of the environment, including the joint capacity of the climate, the ground surface (with the soil as its most important component) and the hydrological cycle determined by and connecting these two factors;

4. The actual level of technology (soil cultivation, nutrient supply, plant protection, etc.) aimed at co-ordinating the ecological demand of the variety with the capacity of the natural environment;

5. A steady increase in the capacity of the natural environment, setting up conditions suitable for more intensive varieties and technologies, i.e. amelioration.

As yet numerical data of acceptable accuracy and general validity are not available for site, period and crop as regards the extent to which the yield depends on the 5 subsystems listed above and on their individual factors, e.g. on the amount of precipitation, nutrient supply, etc. Investigations are being carried out at the Water Management and Amelioration Department of the Gödöllő University of Agricultural Sciences and elsewhere in order to elaborate a method of calculation and to give a precise answer to the question. For concrete cases such calculations can already be made.

PLETSER, J.: Of all the meteorological factors, crop yields in Hungary depend primarily on the amount of precipitation and its temporal and regional distribution. This dependence can be lessened by the correct nutrient supply and cultivation methods, as proved by the results of fertilization experiments where it is always the untreated control and the extremely high rates of fertilizer that cause wide variations in yield from year to year, thus indicating weather dependence. The extremities of temperature are less often responsible for yield losses in Hungarian field crops. Of the climatic factors, only precipitation can be modified. The unfavourable effect of dry periods can be prevented by irrigation. In droughty weather the heat and light conditions are favourable, and if the missing water is supplied by irrigation larger yields can be obtained than in years with favourable precipitation conditions, provided irrigation forms an integral part of the agrotechnics.

POZSÁR, B.: In my opinion the yields of cultivated plants depend to some 30% on the amount of precipitation, to 50% on its distribution during the vegetation period, to 10% on the nutrient supply, to 5% on timely agrotechnical operations and to 5% on the varietal character.

SHMILLIÁR, M.: The yield develops as the resultant of several component forces. In Hungary the yields hardly changed for nearly a hundred years before World War I. The average wheat yield was 13 q/ha in the small farms and 17–21 q/ha on the large estates. An increase of some 50% could be observed between the two world wars, and this has now reached 100%. Within this period production was particularly low immediately after each war, and as soon as conditions settled it began to rise slowly. I mention this example because it shows clearly that the success of production depends primarily on the level of farm management. This includes all kinds of factors: soil cultivation, nutrient replacement, irrigation, variety, plant number per unit area, to mention only the major ones. When these factors are brought into harmony and adjusted to the conditions, the yield will increase at a still higher rate. None of the factors should be given preference over others; they must all be applied together.

SOMOS, A.: If what has been said about the transpiration coefficient holds true, the plants listed will only consume the amounts of water mentioned in the question in the case of a certain yield. It is obvious that when the temperature is favourable for the less heat-tolerant potato, its yield will be relatively larger than the yield of maize and will consume relatively more water per hectare than the given values. Since the order of dependence may also be different under different temperature conditions, and since factors other than those mentioned in the question may also play a role, it seems more likely that the yield depends on the balance of factors, and because temperature is the least liable to humen influence, it is the role of temperature that I should emphasize. This year is a good example of this. In the cool weather paprika gave a low yield even when all the other factors were practically ideal, while the cold-tolerant cabbages and potato gave good yields even when the other conditions were less favourable. At low nutrient levels the efficiency of irrigation is poor, while at high levels of nutrient supply it is outstanding.

SZABÓ, L. GY.: The water demand of each cultivated plant shows a characteristic trend during the growth season. An intensive nutrient supply and optimum agrotechnics make an increased water supply necessary. Apart from the total heat demand, the demand for precipitation (mainly in the initial phase of ontogeny: in most species before or during flowering) is the most characteristic feature of the variety.

SZALAI, GY.: Detailed studies were carried out between 1960 and 1965 in the Füzesabony district (northern part of the Great Plain) on yield fluctuations in winter and summer barley as a function of meteorological factors. A modification compared to the average yield as computed by analytical trends was regarded as a weather induced deviation: this was mostly due to changes in the amount of precipitation. On this basis the greatest difference in winter barley, related with changes in the precipitation conditions, was 3.5 q/ha. Although in 1963 differences as high as 5 q/ha were also encountered, this was mostly the result of thinning caused by early spring frosts. At the same time, in sensitive spring barley, where modifications caused by the weather were almost exclusively the consequence of a shortage of precipitation, the deviation from the trend was as much as 7 q/ha on two occasions.

The extent of differences caused by meteorological factors is gradually decreasing as a consequence of the rising agrotechnical level, as clearly seen in fertilization trials, where in the absolute 0 plots the fluctuation is greater than in those given an optimum or nearly optimum nutrient supply. Throughout my reply there will be repeated references to work done in the course of research on crop estimation methods. The highest yield fluctuation caused by meteorological factors in the last 5 years was 5 q/ha (1975) for winter wheat, 2.7 q/ha (1974) for winter barley and 9 q/ha for maize.

The success of crop production is the consequence of the joint action of various factors, but according to our data the level of nutrient supply has the greatest influence on the yield. This can be demonstrated by the results obtained in the E-184 experiment at Kompolt in the national fertilization trial series. In the four-year long-term experiment the unfertilized control plot gave an average yield of 34.8 q/ha and the most favourable plot 73.6 q/ha over the last two years (1971—72). Since the result was obtained under experimental conditions where the other factors were completely identical, the doubling of the yield must have been due exclusively to the nutrient supply. The rate of fertilization in the high yielding plot was the following:

N 150 kg active agent/ha,
P_2O_5 100 kg active agent/ha,
K_2O 100 kg active agent/ha.

The effect of the soil cultivation method can only be evaluated within certain limits. The yield of an area ploughed when it was too wet and trodden down will probably not reach even 50% of the yield obtained on properly cultivated soil. Considering the methods usually applied and the general level of soil cultivation the method of cultivation may result in yield differences of about 1—3 q over the average of several years, according to literary data.

The productivity of a variety can only be judged properly after ten years of cultivation. There is little sense in comparing the recently certified winter wheat varieties GK szegedi or Mv 8 with Székács and other wheats bred in the Tisza region and grown at the beginning of this century. Within a ten year interval yield increases may be as much as 5%, plus the additional yield surpluses given by varieties which show a higher adaptation to special conditions. This latter can also be taken as 5%. For example, after a late harvested crop the readily adaptable winter wheat variety Jubileinaya is preferred, while on lighter soils early maturity is an important factor. So, on the whole, the effect of the variety on the yield is considered to be about 10%. This leads to the conclusion that the nutrient supply affects the yield trend to some 50%, so the influence of precipitation is estimated to be 10—30%, depending on the nature of the crop (winter cereal, root crops harvested late, etc.).

SZALÓKI, S.: The excessive fluctuation of yield averages (from one region, farm, field and crop year to another) suggests the influence of a great many factors, of which the size and dynamics of the natural water supply are highly important. It should be noted, however, that at present there are very few crops and very few areas where the possibilities offered by the natural precipitation or natural water supplies (including the ground-water as a source of water) are fully exploited. This can be traced back to agrotechnical deficiencies.

It is sufficient to refer to experiments in which 482 q/ha alfalfa dry matter was produced from the total amount of 2418 mm precipitation (including the winter precipitation) in the last 5 full years (1973—77) over an average of 16 lysimeters, each with a surface area of 1 m^2, while on the surrounding plots, where the ground-water a depth of 2.5—3 m contributed to the water supply, nearly 600 q/ha was obtained and with irrigation the yields were over 850 q/ha. The yield averages achieved on farms came nowhere near these figures.

As to the maize, wheat and sugra-beet yields, however, the differences between the better farms and our non-irrigated results are much smaller.

There are, however, considerable yield fluctuations in the non-irrigated treatments as well, indicating that the uneven distribution of precipitation over the years and over the vegetation period has a decisive effect on the yield even if optimum agrotechnics are used. The effects of the different yield factors are, of course, closely interrelated; the yield development is controlled by these factors to an extent varying with the growing site, the year and the crop.

Tóth, M.: The factors influencing the average yield of plant species currently grown in Hungary, in order of priority, are as follows:

- the productivity (characters) of the variety,
- the method of cultivation (agrotechnical methods),
- the nutrient supply, and
- the weather conditions in the given crop year.

Ujvárosi, M.: At the present level of farm management on fertile soils in Hungary precipitation or the amount of water available are, in my opinion, the most decisive factors in forming the yield.

Good varieties able to attain large yields exist for most of the plant species grown in Hungary. Measures can be taken to ensure a good nutrient supply in the soil, and most Hungarian farms do so. Today on the majority of the large-scale farms an adequate standard of soil cultivation is also ensured. However, there is little point in ensuring a high yielding variety, an optimum nutrient level and the best cultivation method if an inadequate water supply in the growth season, or in part of it, prevents the development of the production potential inherent in the variety. The temperature and the number of sunshine hours may also have a considerable influence on the size of the yield, but the varieties currently grown in Hungary are capable of adapting themselves to the given conditions. Good average yields can be reckoned with even when these factors show negative trends. A water deficiency, on the other hand, has much more adverse effects, and in critical periods it may even cause catastrophic yield losses. Obviously, it is still possible to increase yield by developing better varieties and improving the agrotechnics, but these are much less effective than the possibilities offered by a uniform water supply. In large-scale farms working under good natural conditions at an up-to-date level all the conditions necessary to obtain large yields are present except the water supply, which fluctuates between wide limits from year to year. It is to steady this varying factor that irrigation should be used. I have deliberately mentioned the water supply to the plants, i.e. the necessary amount of water, instead of precipitation, because, as I have mentioned before, the water requirement of the plant depends not only on the amount of precipitation during the growth season but also on the quantity of water stored in the soil. The distribution of precipitation is another factor that determines the size of the yield. There are years when the crop must be helped through relatively short periods of drought, and years (seldom) when in many places irrigation is not needed at all because the optimum water supply to the plant is ensured; but often there are arid years when the yield must be assured by irrigation for the larger part of the summer.

In large-scale agricultural production the potential productivity of the variety (under optimum conditions) is taken into account, the optimum level of agrotechnics is provided and the nutrient content of the soil is determined and complemented with the amount of fertilizer required for the planned yield. In the light of these factors the water required by the crop should be supplied in the different phases of development. This is the purpose of irrigation which is always needed when the water content of the soil is insufficient to cover the requirements of the plants during the different phases of development.

VARGA, GY.: The maximum yields which can be achieved for plants (particularly vegetables) on a given area are determined by the productivity of the variety, the nutrient content of the soil and the standard of cultivation method applied. Within these limits the actual yield is decisively determined by the weather conditions, particularly by the amount and distribution of precipitation during the growth season, as well as by the extent to which the temperature and water requirements of the plants are met.

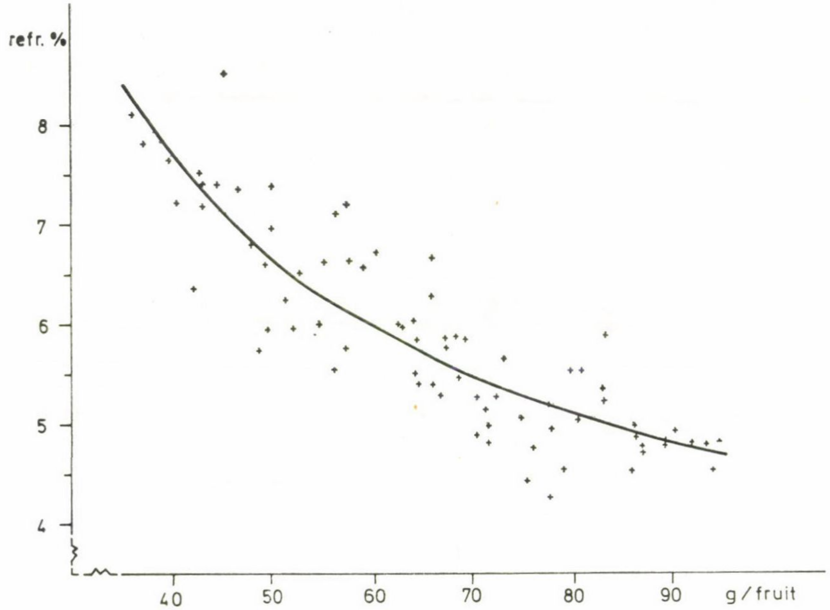

Fig. 2. Relationship between the average weight and dry matter content of tomato fruits under different water supply conditions. Variety: K.42, Gödöllő, 1963–1976. ($n = 77$, $r = 0.886$, $Y' = 2.53 + 20.68 \frac{1}{x}$, $\bar{x} = 65.8$ g/fruit, $\bar{y} = 5.88$ refr.%)

The effect of the amount of precipitation and its distribution in time and of the temperature in the growth season can be seen in long-term fertilization experiments, where greater yield differences are found between the years than between the levels of nutrient supply.

*

PÁL, GY.: The effect of irrigation on qualitative crop features was and still is a much debated question. If the nutrient supply is deficient the protein content in the grains of irrigated wheats is lower; although the sugar content of sugar-beet is reduced by irrigation, the volume of the root crop increases, so that the total sugar yield is substantially higher than in non-irrigated sugar-beet. Are the nutritive and organoleptic values of irrigated crops identical with those of non-irrigated ones?

ALMÁSI, T.: The effect of irrigation on the quality of the yield can only be approached using system analysis. If irrigation is carried out at the proper time in a skilled manner (unless it is aimed at counterbalancing some missing or improperly applied factor) it cannot be disadvantageous to the quality of the crop. The intensive irrigation of winter wheat rarely occurs in practice. If a 6–8 ton/ha or higher level of production becomes a general target in wheat growing a new variety will certainly be needed. This variety will require the close co-ordination of the factors, while its quality must not show any significant decrease. The surplus sugar yield produced by the intensive irrigation of sugar-beet cannot be doubted. Considering the fact that the date of the last irrigation can be fixed, it is possible to avoid, or at least substantially reduce, the unfavourable effect of irrigation on the quality. By choosing the rate and frequency of irrigation for vegetables, grapes and fruit properly it can be ensured that the favourable effects of irrigation will be dominant and those unfavourable from the point of view of storage and end-use will lessen.

ÁCS, A.: A definite stand cannot be taken on this issue either. There are plant species, and varieties of these, in which irrigation, i.e. extra water compared to the natural conditions, causes a problem of this type, while in other species it does not.

Some vegetables cannot be economically grown in Hungary without irrigation; under dry conditions the harmonious effect of their aromatic substances may be reduced. There are plants, on the other hand, whose dry matter concentration decreases as a result of an excessive water supply; the aromatic substances are diluted and the crop becomes "tasteless". Another consequence may be the reduced storability of fleshy fruits with high water contents. In the larger yield resulting from the absorption of the excess water supplied by irrigation the absolute quantity of micro-elements per unit yield may also decrease, which can be harmful from the point of view of nutrition or feeding. In most crops, however, irrigation does not result in quality deterioration.

BALLA, L.: The composition of the yield is evaluated differently for different plant species, depending on the nutritional role of the components. A decrease in the protein content of wheat will not lead to protein deficient nutrition because protein is supplied from other sources. A reduction in the milling and baking quality of wheat may be more significant. With supplementary irrigation the quality of wheat generally improves, but systematic irrigation may cause a deterioration in quality. This is why a wheat type with a hereditarily large thousand-grain-weight and steady quality is required under irrigated conditions.

BORKA, GY.: An excess of water, or water supplied during the wrong phase of development, causes a deterioration in the quality in most agricultural crops, particularly in the generative parts of the plant.

BUDAVÁRI, K.: When irrigation farming is expertly carried out not only is the yield higher, but, using suitable varieties, an adequate nutrient supply, and irrigation carried out at the correct time, the quality of the yield also improves. For example, in sugar-beet the sugar content will only be lower if irrigation is carried out after too long an interval or too late (if the sugar-beet is deliberately "inflated"). The same holds for taste and flavour in fruit.

CSELŐTEI, L.: The relationship between irrigation and the quality of the yield is a complex question. As I have already pointed out, irrigation causes a change not only in the plant water supply but also in other ecological factors which influence the physiological processes (heat, humidity, ventilation of the soil, etc.). In the successive phases of development the plant requires different ratios of these factors; this also depends on the production aims. The effect of irrigation on the quality of the yield may be either favourable or unfavourable.

It should first be made clear what is understood for any given production aim by "good quality" in a given crop, i.e. what properties of the crop are the most important. In the Brassica family, for example, kohlrabi not only develops slowly but also becomes stringy if the water supply is insufficient, while radishes become pithy, and thus lose their value. Dry matter content, which may be greatly reduced by excessive irrigation, is highly important in tomato varieties designed for processing. When tomatoes are used for salad, however, this parameter becomes less important, while the role of size — which can be increased with a better water supply — will be dominant (Fig. 7). In other words, under the same ecological conditions the irrigation requirement of tomatoes for processing is different from that of tomatoes grown for fresh consumption as salad.

To illustrate the above the trends of yield and dry matter production, which vary considerably from year to year, are presented (Fig. 8) as an addendum to Table 1.

When the water supply of the plant increases as a result of irrigation the water content of the fruit will be higher, while the content of aromatic substances will decrease. It was observed, however, in some cases that the sugar content in non-irrigated grapes poorly supplied with water was lower than in properly (not excessively) irrigated

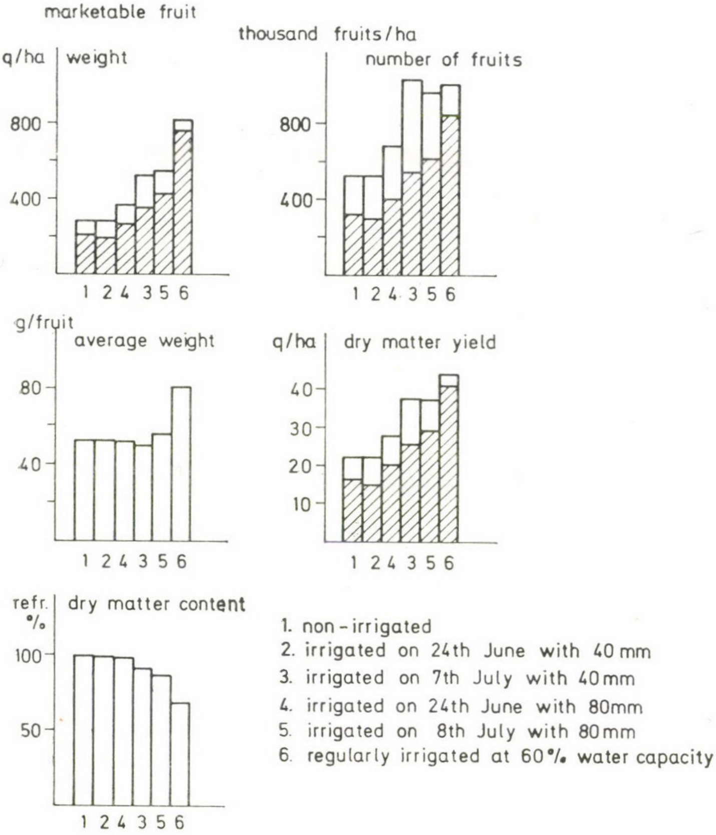

Fig. 7. Effects of different levels of water supply on yield in tomato. Variety: K. Jubileum, Gödöllő, 1976

grapes [Csáky, A. (1969): Az öntözés és a környezeti tényezők hatása a szőlő vízforgalmára (Effects of irrigation and ecological factors on water turnover in grapevine). Final research report. Manuscript, 30).

Another problem is that on occasion precipitation immediately following irrigation causes an excessive water supply, which it is impossible to avoid.

It should be noted that over-large fruits with low dry matter and sugar contents and reduced amounts of aromatic substances may be the result not only of an excessive water supply but also of superfluous quantities of nutrients, particularly of nitrogen. Furthermore, with a view to economically efficient production it may be necessary, temporarily or permanently, to give up certain claims on quality, if the latter is sufficiently compensated by some other factor, e.g. the yield.

The question must ultimately be considred from an economic point of view, and the aim must be to supply the plant with water and nutrients in accordance with the given ecological conditions and the production aims.

Debreczeni, B.: If irrigation is carried out at the proper time and with the right amount of water it does not cause sufficient deterioration in the quality of field crops to reduce their nutritional or biological values. The influence of irrigation on quality greatly depends on the local conditions and on the weather during the current crop year. This is especially so in the case of sugar-beet. The effect of irrigation on the quality can only be evaluated in relation with the nutrient supply.

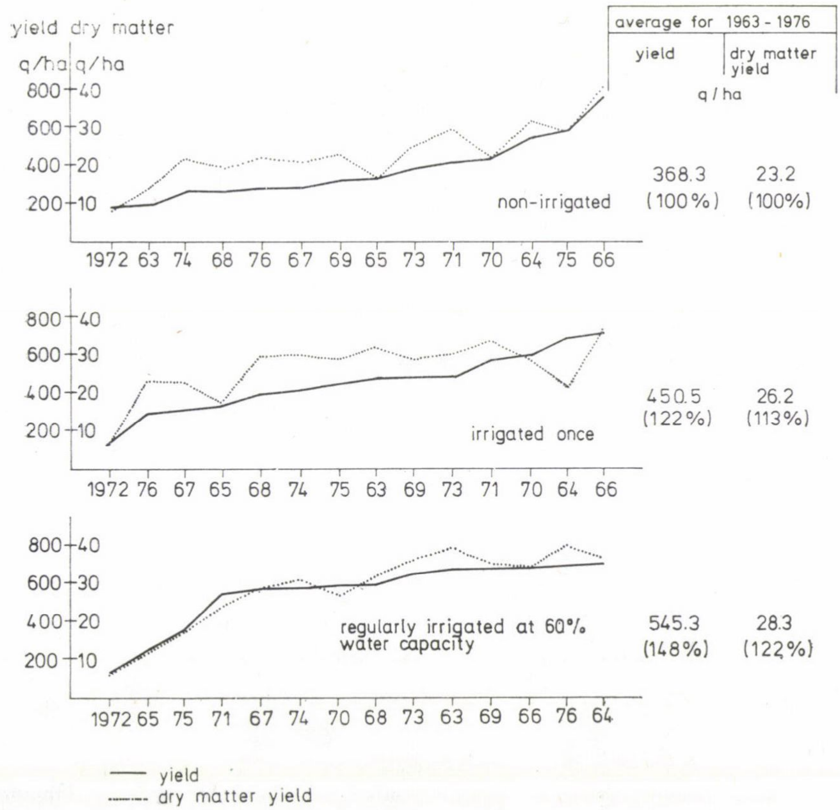

Fig. 8. Size of yield* in tomato with different levels of water supply. Variety: K.42, Gödöllő, 1963—1976

According to our investigations irrigation and nitrogen fertilization have opposite effects on the crude protein content of grain in wheat and maize; while irrigation reduces the protein percentage, nitrogen fertilization increases it. Therefore, in order to attain the highest possible protein yield irrigation should be combined with intensive nitrogen fertilization.

FRENYÓ, V.: Irrigation definitely influences the quality of plants, in the same way as a deficient water supply has an effect on the sugar, protein, fibre and other contents of plants. The position adopted by Margit Terts in this regard is very instructive ("Relations between water and nutrient supply . . ." Publication of the National Agricultural Library and Documentation Centre, Budapest, ETO: 635.1/.7 : 631.67 : 631.8), who writes: "Irrigation can be carried out on two principles: 1) practical irrigation is based on the empirical facts of previous irrigation; 2) physiological irrigation applies the results of biological (cytological, histological, biochemical, biophysical, analytical, etc.) studies." Practical irrigation is based primarily on empiricism, while physiological irrigation tries to rely on the metabolism of the plant. The latter sounds excellent in theory, but whether it can be fully realized in practice may be another matter. Perhaps some well-chosen metabolic indices would simplify the task. It is necessary to know how photosynthesis can best be influenced by irrigation. Changes in the respiration or catalase activity might also indicate what takes place in the metabolism. To study these questions quick methods suitable for application in the field have been elaborated

* Total of class I and II.

and an instrument has been constructed. All this may become particularly important if the amount of irrigation water available is limited.

The uptake of mineral substances and to some extent their processing by the plant can be followed easily and quickly in relation to the irrigation standards by on-the-spot filter paper analysis. For example, the accumulation or reduction of nitrate gives information about what takes place in the cells.

As to the point at issue, it is indisputable that irrigation may cause favourable and unfavourable changes alike in the yield components. The principal task of physiological irrigation would be to determine for each drop (particularly for vegetables) what irrigation standards have the most favourable effects on the quality of the cultivated plants.

Füri, J.: In the case of grape-vine it is only in extremely dry years (e.g. 1963, 1971, 1973) that irrigation improves the qualitative factors (sugar percentage and acid content) of the fruit. According to our data the organoleptic value of the final product (table grapes or wine) did not decrease, and in some cases even increased in response to irrigation.

Gyenge, J.: Unfortunately, it is an undeniable fact, a phenomenon which has long since been observed, that when there is an abundance of water (rainy year, irrigation) the quality of plant products, particularly of juicy ones, is lower than in dry years in spite of the fact that the amount of nutritive substances harvested per unit area is considerably higher. If the number of sunshine hours during the growth season is insufficient, this phenomenon becomes even more marked (grapes, apples, melons).

Irrigation cannot, in my opinion, cause any problems of nutrition physiology if it is coupled with very careful nutrition management. I am thinking here primarily of irrigation on arable land; with horticultural crops I have some doubts, though this is a matter for further investigations.

Irrigation may decrease the storability of the produce and the efficiency of processing; some of the products have less physical resistance. Irrigated sugar-beet, for example, breaks or cracks like glass under the effect of mechanical injuries, and is seldom "bruised". This also increases the harvisting loss. Irrigated apples are much more difficult to harvest without bruising, and more difficult to store; the situation is similar with irrigated onions.

It should be emphasized that the date of the last irrigation, the amount of subsequent precipitation and the number of sunshine hours are of decisive importance.

Fresh produce in particular, which is consumed without processing, may thus be made less palatable due to deficiencies in taste and flavour (e.g. melons, apples, grapes).

Considering that with cereals the amount of nutrient per unit area increases considerably in the case of irrigation, while the difference in composition is minimum, the application of this agrotechnical method cannot cause problems; at most a slight increase in the length of the vegetation period can be expected.

Harmati, I.: It is quite true that the quality of irrigated field crops is often lower than that of non-irrigated crops. In general, the greater the difference between the water supply to crops grown under irrigated conditions compared to those grown without irrigation, the greater the difference in quality. However, a significant deterioration in quality usually only occurs in the case of an overabundant supply of water. In droughty years, on the other hand, the opposite may occur, when irrigation prevents the deterioration of quality by promoting normal development (e.g. in maize). By avoiding an overabundance of water and providing an adequate nutrient level and plant number per ha the decrease in the quality of field crops can be lessened, and in some cases may

N kg/ha	Non-irrigated		Irrigated	
	%	q/ha	%	q/ha
0	4.7	0.34	3.2	0.66
70	6.2	1.65	4.0	1.82
140	8.6	3.35	4.8	2.64
210	9.2	4.20	5.6	4.14

even be prevented. I think, however, that we must accept the fact that an intensive increase in yield involves, in most cases, a lowering of quality indices.

Changes in the digestible pure protein content and yield of alkali salt-grass as a response to nitrogen fertilization under irrigated and dry conditions.

HORVÁTH, I.: The question formulated in the last sentence must again be criticized, as it does not follow from the two examples mentioned.

As regards the example of wheat, it is quite natural that with a better water supply the nutrient demand of the plant will be higher.

In the case of sugar-beet, on the other hand, the total sugar production is the main point, so the fact that under the influence of irrigation the relative sugar content will be lower because of the larger yield does not present a problem. (The problem arises during processing in the form of extra expense.)

Thus, the two examples are not connected with the nutrition-biological and organoleptic values of the product. These would only come into question if the crops were utilized directly. In as much as these properties were adversely affected by irrigation, they could be improved by a better nutrient supply, for instance.

KISS, A. S.: The qualitative characters of plants are differently affected by irrigation; the effect of irrigation also depends on the variety. It has been found that the wet gluten content of wheat decreases under the influence of irrigation by about 5% in the variety GK-3, remains unchanged in Avrora and increases by some 4% in Bezostaya 1. Over an average of six varieties the wet gluten content was unchanged, the total protein content increased by 4% and the farinographic value showed a similar increase, which suggests an overall qualitative improvement. In soybean an increase in crude protein of about 6% and a simultaneous 8—9% decrease in crude oil have been pointed out (over an average of 14 varieties). In vine-growing no significant changes in either the sugar content or the acid content of the grape juice have been caused by any type of irrigation. With a fifty per cent increase in irrigation water the crude protein content of horse bean has been found to decrease by some 2%, with a simultaneous increase of 2% in the carbohydrate content and an increase of 9% in the oil content. It is worth mentioning that the valorigraphic value of the wheat variety Jubileinaya 50 increased in dry years (1973 and 1974) and decreased in wet years (1975) as a response to irrigation. Comparing the data obtained with the above crops of different character it can be concluded that while irrigation generally has no significant effect on the quality, an overdose of irrigation water may cause a deterioration.

LELLEY, J.: Irrigation has an unfavourable effect on certain qualitative features in many cultivated plants. The main reason for this is lack of knowledge of the best method of irrigating these crops and of the most favourable way of supplying them with nutrients. If the optimum amount and time of nutrient and water supply to the different varieties on a given soil were known, there would certainly be much less deterioration in quality. There is still much to be done in this field.

Some qualitative determinants are biologically antagonistic to the quantitative determinants. In this case the possibilities of breeding are very limited. Thus, whenever the quantitative increase is inversely related to the improvement in quality a solution can only be expected from the breeders, though even this is not very promising.

LŐRINCZ, J.: Irrigation may have both harmful and favourable effects on the components of plants. For example, wheat may have a higher gluten content and grapes and fruits may be more tasty when adequately supplied with water and nutrients. A well-balanced water and nutrient supply can improve rather than deteriorate the quality of crops.

MIHÁLYFALVY, I.: Irrigation generally reduces the dry matter content of any plant product. If irrigation is applied in the wrong amount and at the wrong time a deterioration in the quality of the yield will ensue. The yield surpluses obtained as a result of irrigation generally compensate for the harmful effects of water supplements. With some crops (e.g. sugar-beet, apples) it is important to be able to store the produce for a long time, and this must be taken into consideration when planning the irrigation system. In the case of these crops particular attention must be paid to the date of the last irrigation before harvesting. Sugar-beet, for example, must not be irrigated for the last 5—6 weeks before harvesting, in the interests of digestion and storability. If the irrigation date is properly chosen, the organoleptic properties of the produce from crops given water supplements (with the exception of juicy produce) are the same as those of non-irrigated crops.

PÁSZTOR, K.: From the point of view of nutrition biology and as regards the organoleptic properties, the yield of irrigated crops cannot be worse, and may on occasion even be better.

This is naturally a function of numerous factors. It depends, for example, on whether the necessary life conditions have been adequately and harmoniously provided in accordance with the requirements and biological character of the plant concerned. Excessive irrigation or an overdose of fertilizer may upset the balance and may ultimately cause unfavourable changes in the product.

PETRASOVITS, I.: The effect of irrigation on the quality of the crop has not been sufficiently studied in Hungary as yet, although its practical importance is extremely great. One frequently encounters the opinion that the effect of irrigation on the quantity of yield is so important that a possible deterioration in quality is negligible by comparison. This standpoint is inadmissible. Well-known examples of qualitative deterioration are the reduction in the protein content of wheat grains and in the sugar content of sugar-beet. The human aspects of carrying out regular nutrition biology examinations on fruits, grapes and vegetables are even more important. A reassuring answer to the question is only likely to be given after 10—15 years of regular irrigation trials. Practical experience shows that in the first years irrigation mobilizes large quantities of high quality "frozen" nutrient stock in the soil which under the conditions of regular dry farming are only utilized after a long period if at all. One such highly important element in rough fodders is copper. In almost all cases there are sufficient quantities of available copper in the soil to give a satisfactory copper content with 50—60 q/ha yields of alfalfa hay. For the 100—120 q/ha hay yield obtained with irrigation over a long period the natural copper supply is not generally enough, as has been shown primarily by the results of investigations and practical experience in France, where a copper deficiency caused serious brucellosis, etc. in cattle.

The dual nature of the solution should be emphasized. First, the joint effect of different qualities of irrigation (amount of water, date and method) and different standards of production technology on the quality of the crop on the same site should be examined. Secondly, ways of eliminating the deteriorative effect on the product through better co-ordination between irrigation and technology should be found. It is worth paying special attention to studies on the application of trace elements and foliar nutrition.

PLETSER, J.: Irrigation must always be co-ordinated with other agrotechnical factors. More irrigation does not always mean more yield. Quality can be both improved and deteriorated by irrigation. If the irrigation is adjusted to the variety, nutrient level and agrotechnics, it is possible to produce high quality crops. Economic factors must also be taken into consideration when determining irrigation levels. If the price of the product depends on the quality, this is also part of the economic efficiency. A shortage of water may cause a deterioration in the quality of the produce, but irrigation water supplied in excess may also have similar consequences. Overirrigated and overfertilized sugar-beet crops with lower sugar contents are not welcomed by the sugar factories because they increase the production costs of sugar. The determination of prices according to quality has not stopped the irrigation of sugar-beet, but has made farmers balance irrigation with fertilization. Too much water and too much nitrogen may also cause wheat to lodge. If the price depended on the qulity the agrotechnics might improve in this field too. When supplying irrigation water, unexpected rainfall must always be reckoned with, otherwise an excess of water in the soil will threaten both the quantity and the quality of the yield. For example, soil with a water capacity of 300 mm in the upper 1 m layer must not be saturated with more than 200—250 mm.

POSGAY, E.: It is rather inaccurate to ask how the quality and quantity of yield develops in irrigated and non-irrigated crops. Quality and quantity are influenced by the varying amounts of water available in the different phases of plant development. As an agrotechnical tool irrigation is aimed at promoting the realization of production goals for both quality and quantity, so the water supply provided during the growth season must suit this purpose. In the case of sugar-beet, for instance, the maximum or nearly maximum amount of sugar should be produced in the smallest possible root crop. The water supply required for this purpose is not the same as that required to obtain the maximum root crop.

In the case of soybean an abundant water supply results in an increased protein content; alternatively, it can be said that drought reduces the quantity of protein.

Thus, the optimum water supply varies with the production aim.

In practice the aim of farm production is to produce the highest possible profit. The farms thus endeavour to achieve the production indices in which they are financially interested. If, for example, apples, paprikas, potatoes, etc. are paid for according to categories based on size, the producer tries to grow as many large apples, paprikas, etc. as possible. If any inferiority of such produce compared to smaller ones with respect to taste and flavour is not expressed in the price, it will not influence the producer's work. But if it affects the price, the producer will change the agrotechnics so as to attain maximum profit by fulfilling the new requirements.

By controlling the water supply it becomes possible to modify the nutrition biological, organoleptic and other properties of the crop. Too much or too little water may be equally disadvantageous.

POZSÁR, B.: In the case of a critical water supply the dry matter content in the tissues decreases in consequence of irrigation, since the activity of enzymes bound to the structure is the highest with a water content of 55% and gradually decreases as the water content approaches 80%.

SHMILLIÁR, M.: The negative effect of irrigation can be observed in most cases when it is used in isolation from other production factors, as the only means of increasing the yield. In the case of sugar-beet, if the water content of the soil can be kept at the right level, a large root yield can be achieved in such a way that the sugar content will only decrease to a minimum extent, if at all. A good example was the year 1978 when the irrigation area and yield of sugar-beet increased on a national scale, and the sugar content was also higher than in the previous year. Healthy plants must be grown: this can best be achieved through the co-ordinated application of all agrotechnical operations. All the factors required for the proportionate development of the yield components can be found in the healthy crop.

SOMOS, A.: The effect of irrigation on the quality of yield may be either positive or negative. As a response to irrigation the quality, particularly the nutrient content, generally decreases, though this is not always so, and in the case of vegetables in particular the nutritive value is determined by other properties such as size, earliness, lower fibre content, etc. The taste, flavour and vitamin content are not influenced by irrigation as much as the nutrient content is, though the effect of excessive irrigation is unfavourable. Little is known of the extent to which the unfavourable effect of irrigation could be counterbalanced by a proper nutrient supply. This effect could quite possibly be lessened even if it could not be fully eliminated.

SZABÓ, L. GY.: Qualitative features do not, in my opinion, change significantly. Certain special viewpoints are manifested in the case of species providing green mass, and others, due to the different nature of the biochemical processes, for organs storing nutrient reserves (seed, tuber, storage root, etc.). Secondary metabolites are generally formed more intensively under extreme conditions (e.g. volatile oils, aromatic substances, alkaloids, etc.), so with these plants it must be decided whether "more or better" should be produced.

SZALÓKI, S.: The extent and manner in which irrigation influences the quality of the plants varies with the variety.

The size of the crop is definitely enhanced by an adequate water supply, and this often leads to an improvement in quality as well (e.g. in potatoes, fruits and certain vegetables).

The quality indices of rough fodders also show more favourable trends when the crops are well supplied with water, because the fibre content decreases while the protein and easily digestible carbohydrate contents increase.

Poor quality is often the result of infections by pathogens. Irrigation is generally thought to promote the spread of diseases, though this is not always the case. In maize, for instance, infection by smuts in non-irrigated treatments is the most severe in droughty weather.

TARJÁN, R.: I am afraid the problem is much more complicated than the question suggests. It was chiefly the fact that changes were observed in the protein content of wheat and in the sugar content of sugar-beet during the industrial processing of these crops that drew attention to the strong influence of irrigation on the development of plants and on the quantitative and qualitative ratios of the nutrients contained in them. Unfortunately, studies and experiments in this field — even in the international literature — are very few in number, and are mostly confined to the industrial utilization of one or another industrial crop. Consequently, data on those components of the nutrient content which are connected with the "biological value" of irrigated plants are few and insufficient. From the fact that the sugar content in beet, for example, substantially changes no far-reaching conclusions can be drawn concerning other plants not subjected to industrial processing; nevertheless, there is reason to suppose that changes take place in certain vital metabolites (vitamins, micro-elements, enzymes, etc.). To carry out investigations in this direction would definitely be desirable, particularly in countries where agricultural technology is sufficiently developed, and where the laboratory network of the food industry and nutrition science is properly equipped with instruments and experts and is capable of approaching the problem.

Our Institute, in co-operation mainly with plant breeders, has in the past decades carried out investigations to clarify the favourable, or possibly unfavourable, changes occurring in the course of breeding. The rapidly developing technology of the food industry also made it necessary to study the effects of certain processing operations, in order to throw light upon possible changes in the biological value. Up to now, however, owing to the large volume of chemical substances used, agrotechnics has restricted our investigations mostly to the determination of any "residues" which may be found. I think it would be advisable to start systematic research aimed at clarifying the influence of certain agrotechnical operations (soil amelioration, fertilization, irrigation, application of herbicides, stimulants or inhibitors, etc.) on biological values. I am in the position to announce that our Institute will begin these investigations this year, and we shall try to improve our methods so that research of this character in the future, in co-operation with the laboratories and experts of the agriculture and food industry, will yield satisfactory results.

TÓTH, M.: Irrigation must not cause a deterioration in the standard quality (sugar yield, taste and flavour, etc.). Difficulties arise when the various production factors (nutrients water, temperature and insolation conditions, etc.) are not co-ordinated, i.e. when irrigation is not properly carried out.

UJVÁROSI, M.: If the irrigation of plants is carried out as described previously and only the optimum water supply for the different varieties is provided, there need be no fear of a change in quality. To attain regular large yields the proper nutrient supply must, of course, be ensured.

VARGA, GY.: Irrigation may have different effects on the qualitative features of plants. The commercial value of vegetable crops grown for fresh consumption is related mainly with the shape and size of the produce. From this point of view the effect of irrigation is undoubtedly favourable because of the more attractive fruits with larger average weights. The effect of irrigation on quality is favourable in the case of cucumber, for instance, as it results in less deformation, and in produce with a length/diameter ratio favourable for the preserving industry.

Irrigation increases the yield of tomato partly by increasing the average weight of the fruit. Under given conditions of variety, soil and nutrient supply, different weather and irrigation conditions cause opposite changes in the average weight and dry, matter content of tomato fruits. Their correlation is of a negative, hyperbolic nature as shown in Fig. 2.

Consequently, the effect of irrigation is often unfavourable as regards fruit quality. If the water requirement of the plants is fully satisfied and water consumption is excessive, there may be a considerable deterioration in fruit quality. With an optimum nutrient supply, however, and a lower amount of irrigation water applied at the correct time, the unfavourable effect can be reduced to a minimum.

The dynamics of water supply during the growth season may influence the yield in several ways: Irrigation applied at different dates and rates had a different effect on the number of fruit, the yield per ha and the water-soluble and total dry matter content of tomato. Figure 3 presents data obtained in tomato irrifation trials; the accumulated values of the amounts of precipitation and irrigation water are shown as a function of the total heat units during the vegetation period. The three curves show the water supply averages over several years in the treatments which gave the highest average fruit weights and dry matter yield and the largest quantity of water soluble dry matter in the fruit in the different experimental years.

The maximum refraction percentage, occasionally exceeding 7%, was obtained under absolutely dry conditions with the tomato variety examined (curve C). To obtain

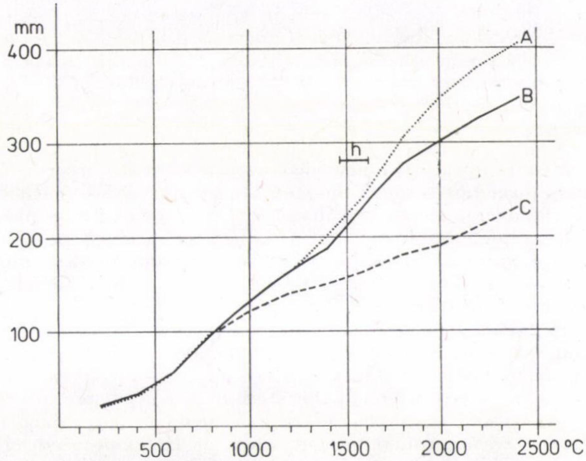

Fig. 3. Optimum water supply to tomato from the point of view of the average weight (A, g/fruit), dry matter yield (B, t/ha) and dry matter content (C, refr.%) of the fruit. Variety: K.42, Gödöllő, 1963—1971 (*h* = date of first picking)

maximum dry matter content 100—120 mm more water was required (curve B). In these treatments the average refraction percentage was 5.3%, but the yield increased substantially. A larger amount of water further increased the average weight of the tomato fruit, but caused a reduction in the dry matter yield (curve A).

Thus, if irrigation is applied taking the temperature conditions and the development stage of the plants into consideration, various effects can be produced, so the aim of production may determine the extent of the water supply. In the case of fresh consumption larger average fruit weight provides better marketing possibilities, while for processing purposes a higher dry matter yield and refraction percentage and a lower average fruit weight are favourable.

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PÁL, GY.: **After humic hot nights, drops of water forced out of the xylem appear on the leaf apices of young plants. This phenomenon, which is called guttation, is a consequence of the root pressure by which the plants excrete harmful materials (NaCl, B, etc.) accumulated in their organisms. Do you think that the plant is able to absorb water through its stomata from the air humidity precipitated on its leaves? In other words, is the process of guttation a physiological phenomenon which also takes place in the other direction?**

ALMÁSI, T.: The question concerning the reversible nature of guttation is only seemingly theoretical. The data on the widely used practice of foliar nutrition prove that the initiative may be taken by the environment. The practice of sprinkler irrigation used in West-European orchards also indicates that this possibility does exist, though due importance is not attached to it. Nevertheless, I still maintain my hypothetical opinion, which is based on practical experience.

BORKA, GY.: Guttation is a consequence of root pressure, while the water uptake of the leaf is a process related with the nutrient uptake. In the latter, physiological and physical forces both have a role, while guttation, although it takes place under definite physical (environmental) conditions, is definitely a physiologically controlled process.

BUDAVÁRI, K.: To give a correct answer experiments should be carried out on various plants (since salt tolerance, for example, also varies from plant to plant).

DEBRECZENI, B.: Terrestrial plants generally take up water through their roots, but the water uptake of the roots is greatly influenced by transpiration. The root is the main, but not the exclusive, site of water uptake. Water uptake by the aboveground parts of the plant may also play an important role in the water metabolism; in a dry zone, for example, the absorption of dew may be of great significance. Water uptake by the aboveground parts is the larger, the higher the saturation deficit in the leaves. Guttation is the opposite physiological phenomenon. The re-absorption of the water discharged at the apices of leaves during guttation is a function of the humidity and temperature of the environment.

FRENYÓ, V.: Possible water uptake through the stomata is not the inverse of guttation, because guttation takes place not through the stomata but through hydathodes or hairs. In this way some of the excess substances dissolved in the water may also be excreted from the plant. Microscope examinations of dried guttation drops provide a simple proof of the fact that the more phosphate is given, for example to the roots of young cereals, the larger number of phosphate crystals appear about half an hour later in the drop of liquid excreted from the plant. The dried phosphate solution forms characteristic crystals. These patterns, which resemble pine-branches, can be identified with known solutions, and can naturally be checked by means of micro-analytical reactions too.

The question now is whether water or nutrient solutions can also migrate inwards either in the same way or through the stomata, or even perhaps through the cuticle of the epidermis cells. If the problem is not divided into three parts it is easy to answer at least as far as water uptake is concerned, as Hales pointed out as early as 1747 that the plant was able to take up water through its leaves. The only point to be cleared up is how the water is able to penetrate the cuticle.

Various different views have developed in this respect. For example, basic compounds may cause a certain degree of saponification in the cutin, which may then promote the infiltration of liquids. Some authors think the ectoderm may be a possible route of penetration.

Wetting the leaves from time to time is favourable to the development of the foliage even when the plant, grown for example in an aquiculture, is satisfactorily supplied with water. Particularly interesting are the experiments carried out by Lausberg, who found that in the case of overabundant nutrition the plants died unless the leaves were occasionally sprayed. Under such circumstances the majority of plants are not able to excrete the superfluous nutritive salts through the leaf surface, e.g. by so-called cuticular excretion. The fact that such excretion really existed had been observed by Saussure, who observed that when intact leaves were dipped into distilled water after having been carefully washed, mineral substances, mostly potassum, were dissolved out of the leaves through the cuticle. When the water was evaporated mineral substances were left behind in the vessel.

All this suggests that especially in regions where night dew scarcely forms sprinkler irrigation definitely has a more favourable physiological effect than either trickle irrigation or flooding. Sprinkler irrigation can be combined with spray fertilization. In this case the plant can take up the necessary ions through its leaves, sifting out the superfluous ones at the same time.

The most direct evidence of material uptake through the leaf has been produced by the isotope method. For example, phosphate applied on the lower leaves of fruittrees could be pointed out in the upper leaves a few hours later.

FÜRI, J.: In my opinion the vine is able to take up not only water but also the nutrients dissolved in it through the stomata of the leaves and to utilize them in building up its organism. The positive effect of a low rate of refreshing irrigation or foliar nutrition that was observed in experiments over several years gives evidence of this.

GREGUSS, P.: The question is not very easy to answer in a few words because the water economy of leafy plants — that is, the uptake, processing and discharge of water — is the result of highly complicated processes, so a correct answer can only be given with a knowledge of the anatomy and physiology of the leaf.

In the leaves of green plants three important processes take place: assimilation, respiration and transpiration. In accordance with the division of labour there is differentiation in the interior of the leaf. The foliage leaves are bordered on the upper and lower side by an epidermis which consists of one or more cell layers. The epidermis is covered by a thin cuticle which prevents the superfluous water content of the plant from leaving too quickly (cuticular transpiration). The epidermis cells are filled with water and generally serve the purpose of filtration. Below the epidermis the mesophyllum is divided in two parts. The upper part is the palisade layer which normally does the work of assimilation; its cells are close set, though there are intercellular spaces between them. The cells contain numerous chlorplasts. The other part is the spongy parenchyma layer with fewer chloroplasts in the calls. The continuous air passages between the chloroplasts are connected with the intercellular space and the openings of the stomata. The stomata are the organs through which the oxygen produced during assimilation, the carbon dioxide produced during respiration and the vapour arising in the course of metabolism are expelled. The stomata originate from epidermis cells through transformation and are usually found in larger numbers on the lower surface of the leaf. Their cell-walls are thickened in two ways; the perpendicular walls are thin and play an important role in the opening and closing of the accessory cells (they work as vertical or horizontal bellows). Unlike the epidermis cells they contain chloroplasts. The clowing and opening are controlled by the turgor pressure, the outside temperature, the humidity and the atmospheric pressure. When water or vapour reaches them they swell and move apart slightly, and the water departs in the form of vapour through the opening thus produced.

All this can be demonstrated by means of a simple experiment. The upper and lower surfaces of a largish leaf freshly detached from the plant (*Geranium*, *Syringa*, *Petunia*, bean, etc.) are covered with blue cobaltous chloride paper dried out above a flame, then the leaf and the cobalt paper are pressed between two glass plates. A few minutes later the dry blue cobalt paper on the lower surface of the leaf becomes pink under the influence of the released vapour, while it remains bluish on the upper surface, thus proving that water vapour has left the leaf.

However, this still does not prove that there are stomata there; the latter can be demonstrated by means of another experiment. A cork fitted with a thin glass tube with an elbow bend is inserted closely in a large test-tube containing a freshly detached *(Petunia, Tradescantia)* leaf covered with water, leaving an air-space between the water and the cork. If some of the air is sucked out of the test-tube, the reduction in the air pressure causes the air and vapour contained in the leaf to depart through the stomata in the form of bubbles. On the leaves of monocotyledonous plants the stomata are arranged in rows running lengthwise at a certain distance from one another, while in dicotyledonous plants the stomata are scattered over the leaf surface. This experiment proves that the plant is permeable by gases and that the gases can leave through the stomata. This experiment does not, however, give an answer to the question of whether the stomata on the leaf surface take part in the uptake of vapour or water. In normal weather the stomata are generally open, so the vapour produced by the metabolic processes, the oxygen released during assimilation and the carbon dioxide produced during assimilation and the carbon dioxide produced during respiration can freely depart from the plant. If, however, rain, dew or irrigation water reach the leaf, i.e. the surface of the leaf becomes covered with water, the question arises whether the plant is able to utilize this water, i.e. whether it is capable of water uptake as well as guttation. This can be answered by means of another experiment. If dicotyledonous petunia and monocotyledonous tradescantia leaves are placed in a large thick-walled glass pipe or test-tube, and the glass pipe or test-tube is filled to the top with water, the slightest pressure produced by trying to press down the water with a cork or rubber stopper (or with a finger) will result in the water contained in the test-tube penetrating the leaf through the stomata, as proved by the discoloration of the leaf. Thus, the structure of the stoma allows the penetration of both gases and water, i.e. green plants can take up water not only through the roots but also through the leaves. *In vivo*, however, this process only occurs when the environment of the leaf is saturated with vapour (e.g. in the humid atmosphere of the tropics, or after rainfall or irrigation). This is also demonstrated by the following experiment. When the stomata of illuminated living bean plants or other leafy plants are open they let through not only gases but liquids too. If a brush dipped in petrol etder or xylol is run over the lower surface of the leaf, the liquid enters the plant through the stomata, as proved by the discoloration. If, on the other hand, the brush is run over the upper surface of the leaf, discoloration hardly occurs at all, because there are no stomata on the upper surface of the leaf. The latter two experiments show that leafy plants can take up some of the water they require through the leaves. This process is the opposite of guttation.

This water absorption capacity of the plants is útilized in practice when sprinkler irrigation or foliar nutrition is applied. In such cases the minerals and hormones contained in the spray can enter the plant. As a response the plants grow and develop faster, flower earlier and give a better yield. Wuxal is a well-known example of such sprays.

GYENGE, J.: I can give no physiological explanation of the question, since I have not carried out investigations of this character, nor have I read about results of this kind. However, according to my observations in practice a process the reverse of guttation must definitely take place, otherwise there is no way of explaining the physiological phenomena occurring in crops during dewy nights in late July and early August.

In the evenings after hot summer days plants which were compelled to furl up their leaves in the daytime prepare to receive the evening vapour. Moreover, it is very interesting that if the middle parts of fields are observed from aircraft one never meets with the phenomenon of leaf furling. It is highly improbable that furling up the leaves keeps the plant alive or urges it to display more intensive activity; this much more aptly describes the phenomenon whereby maize, sugar-beet, soybeans, sunflower, sorghum, etc. unfold their leaves to receive as much moisture as possible. If this were not so, the plant would endeavour even at night to retain water by reducing its transpiring surface.

It may be mentioned that alfalfa crops deprived of their previous growth do not develop during this period, not because of pests, which may also act as growth inhibitants, but because they cannot take up water from the atmosphere. Tillering and growth are physiological processes requiring much water and energy.

Furthermore, the water content of the soil does not change in the daytime, and dew falling to the ground does not reach the root zone.

Studying the intensity of sap transport it is found that the quantity of sap flowing from the roots of plants cut off at ground level is much larger in the morning hours than in the afternoon.

HORVÁTH, I.: To be precise: guttation generally occurs when, owing to environmental factors, transpiration is inhibited. It is thus a discharge of water in the liquid state and is neither "the excretion of harmful materials" nor "the precipitation of vapour on the leaves of the plant". Vapour precipitated on the leaves of the plant must mean dew, and the conditions for dew formation are clear weather and intensive eradiation at night. Thus, dew formation, in general, is characteristic of rainless periods. Water uptake through the stomata is possible, so dew is an important source of water for the plants.

The water released by guttation is not reabsorved, as it generally appears on the hydathodes at the edge of the leaf and usually drips off the leaf.

KISS, A. S.: Guttation occurs when the air humidity is maximum and the plant cannot lose superfluous water through transpiration. In this case the water is excreted in the liquid state through the hydathodes, which are generally found at the leaf apices. Thus the plant is able to ensure a balance between water uptake and loss. Since guttation is the disposal of excess water, water uptake through the stomata is simultaneously suspended. By the time water uptake through the stomata is possible again it is highly unlikely that the guttation drops will not have evaporated before reaching the stomata. The situation is different with the cucurbitaceous plants, for example, where the site of guttation is in the hollow petiole and stem instead of the leaf, and the water can thus be immediately utilized in case of need, as it cannot evaporate from the closed space.

To sum up: with some special exceptions (Cucurbitaceae) there are spatial and temporal obstacles to the re-absorption of guttation drops excreted through the leaves.

LELLEY, J.: If plants are able to take up nutrients or toxins dissolved in water through their leaves, then there is obviously nothing to prevent the absorption of moisture in the same way. There are simple plants which cover their water requirements exclusively from the vapour or dew taken up through their leaves. This is not characteristic of the cultivated plants, but experimental and practical data prove that this method of water uptake is possible.

LŐRINCZ, J.: The leaf must be able to take up water through the stomata if it can take up nutrients in this way (foliar nutrition). In most cases limp leaves regain their turgor when placed in water, undoubtedly by absorbing water through the stomata.

NÉMETH, S.: I think plants are able to take up water through the stomata.

PÁSZTOR, K.: To settle this question physiological studies are needed. The plant is able to take up water and nutrients dissolved in water through the stomata. This is the basis of successful spray fertilization (this has been experimentally proved by T. Halász).

According to the experience I have gained in practice, vapour precipitated over the surface of plants favourably influences the extent of transpiration and the process of assimilation. (The transpiration can also be affected by the application of various chemicals.) The amount of water entering the soil through the precipitation of vapour is not negligible either. According to G. Szász (Debrecen) it may amount to 60 mm a year.

PETRASOVITS, I.: In our own investigations the effect of air humidity has often been studied. The data obtained in a growth tent with young maize plants are presented below. Two air humidity (U_k) levels (relative humidity: 52—64% and 83—88%, respectively) and three soil moisture levels were set up.

The dry matter production during the period of examination is shown by the following figures:

Air humidity, U_k	Soil moisture, $D_{v\%}$		
	40	60	80
	g		
52—64	410	630	710
83—88	430	540	430

The data reveal that in the young maize plant the highest dry matter production was the result of the joint effect of 52—64% air humidity and 80% available water content in the soil.

However, when the water content of the soil ($D_{v\%}$) was 40, at this low level of soil moisture it was the higher air humidity that increased the dry matter accumulation.

These and similar observations lead to the conclusion that a better water supply in the leaf zone of the plant stand is able to make up, to an extent depending on variety and phenophase, for a relative water deficiency in the root zone. This ecophysiological phenomenon is utilized by methods of irrigation which increase the humidity of the atmosphere, e.g. the impulsive irrigation of tea-shrubs in the Soviet Union, the "humidifying irrigation" of orchards in Italy, etc. These methods are spreading rapidly.

PLETSER, J.: The plant generally takes up water from water vapour which is precipitated on the leaves, except when this is made impossible by the high internal pressure. The water taken up through the cuticular layer of the epidermis and the stomata carry the systemic pesticides to the interior of the plant, and this is also the basis of foliar nutrition. Such operations are carried out when the leaves are dry. The effect of so-called "refresher irrigation" is also due to the water taken up by the foliage, the increased humidity and the lower degree of transpiration of leaves cooled down through evaporation.

POZSÁR, B.: The leaf cells are capable of taking up water from dew, but in the case of vapour saturation the transpiration decreases and so does the mineral nutrient level. In droughty periods the yield of wheat grown in river valleys is hardly reduced by lasting dry weather. Soybean also gives record yields in river valleys. Maize leaves which curl up on dry days recover their turgor by dawn because of water uptake.

Somos, A.: It is a well-known fact that plants take up nutrients through the leaves, and these nutrients can only enter the plant when dissolved in water. Spraying wilting plants with water restores the turgor, which proves the possibility of water uptake through the leaves. Only a restricted amount of water or nutrient solution can be taken up in this way; it cannot compare with the amount of water and nutrients absorbed by the roots, but it may counteract the adverse effect of a rapid water loss.

Szabó, L. Gy.: Guttation is not very characteristic of field crops in Hungary. The process is the consequence of too high a turgor pressure and is not reversible. Precipitated water vapour does not penetrate through the stomata, but the vapour produced enters the mesophyll of the leaf.

Szalai, I.: In the question the water uptake of leaves is brought into partial connection with guttation, as if it were the inverse process of guttation. There are two types of guttation:

a) The water departs through the hydathode, a modified stoma incapable of closing and opening, connected with a vascular bundle, where the water discharge is caused by overpressure in the tracheae.

b) There are hydathodes with the task of secreting superfluous salts (*Saxifragaceae, Plumbaginaceae*, etc.). They are also called "desalting" glands. Water is, of course, also excreted with the salts.

Thus, the water uptake of leaves cannot be regarded as the inverse of guttation; only water uptake through the stomata can be discussed, as is quite correctly pointed out in the second half of the question. My answer to this is the following.

Every living cell which is not in a state of turgescence has a suction force and takes up water from its environment. Leafy shoots detached from the plant remain fresh for a longer period if the surfaces of the leaves are wetted with water. On examining the water uptake of leaves the following questions arise:

1. What forces take part in the water uptake of leaves?
2 How do the leaves take up water?
3. On what factors does the rate of water uptake depend?
4. What is the biological importance of water absorbed through the leaves in the water regime of the plant?

1. The osmotic pressure. If leaves which have wilted to different extents are placed in water and the amount of water taken up is expressed as a percentage of the fresh weight it is found that the greater the vapour pressure deficit (wilting), the faster the rate of water uptake.

2. The leaves were first thought to take up water through the stomata, but this theory was soon discarded. If the penetration of various solutions (Fe-citrate and Fe-sulphate) is followed by means of the Prussian blue reaction it is found that most mono- and dicotyledonous plants take up water through thin-cuticled epidermis cells above the vascular bundles. However, the water absorbed only moves in the cell-walls and does not enter the cytoplasm. By the use of fluorescent stains (e.g. berberine sulphate) thin epidermal hair has been found to take part in the uptake of dew, while thick hair (e.g. Verbascum) has a protective role but does not take up water.

3. The rate of water uptake depends on

a) the diffusion pressure deficit (DPD) of epidermis cell contents,

b) the extent of cuticular resistance.

According to the results of relevant examinations the mesophytes take up water at the fastest rate. Although the cuticle is permeable to water in both directions, water uptake through the leaf can only be spoken of in the case of young leaves. The water uptake ratio of young to older leaves in the same species is about 9 : 1. The lower leaf surface generally takes up water at a faster rate than the upper one, although the stomata do not participate in the water uptake.

4. Has the water uptake of leaves any biological importance? To settle this question wide ranging investigations were carried out in Arizona at the Agricultural Research Institute (1950). Tomatoes were grown in light, medium heavy and heavy soils. The surfaces of the pots were sealed with paraffin. As soon as the plants began to wilt (at wilting point) they were sprayed with atomized water. The result was surprising: not only did the plants become turgescent, but the water content of the soil also increased. The details can be seen in the table on the next page.

Soil	Water content of soil at the beginning of the experiment %	Water content of soil at wilting point, %	Water content of soil as a result of moistening the leaves	
			after 24 hours, %	after 48 hours, %
Light	12.5	6.5	18.5	20.2
Medium	22.7	11.9	25.0	27.0
Heavy	36.9	20.0	39.5	47.2

The water was not only absorbed by the leaves but also excreted by the roots. Was this an active secretion of water? To prove this, the roots of the tomato plants were placed in hermetically sealed empty Erlenmayer flasks, then the leaves sprayed with water. The roots exreted water into the empty flasks, in which Ca, Mg, Na, PO_4, NO_3, NH_4 and Cl could be pointed out. This and similar experimental results were, however, challenged by several researchers, who demonstrated (by cooling down the flask) that it was a case of condensed water (produced in the course of root respiration). The various, highly contradictory experiments were continued and led to the final conclusion that this water discharge could not be regarded as an inverse transpiratory flow, because the roots excreted water even when the shoots had been removed. To sum up:

1. the present standpoint does not exclude the possibility of leaves taking up water from the vapour content of air, rain or dew, but this amount of water is negligible, being only a few percentage of the transpiration loss;

2. more water evaporates in unit time from the surface of a wet leaf than what the same leaf surface is able to take up from the environment. There are very few species (mainly desert plants and epiphytes) whose leaves have been fully specialized for the uptake of water from rain and dew.

SZALÓKI, S.: It is known that if there is a lack of turgor an intensive negative capillary potential (suction force) develops over the whole surface of the plant, including the leaves. Consequently, as long as this state exists any water reaching the plant surface will be absorbed.

When the leaf cools down vapour precipitates not only on the external surface but also on the so-called internal surface, which communicates with the intercellular space. From here the water can easily enter the cells. Apart from this, if cuticular transpiration is possible, there is no reason why water should not be absorbed through the parts covered by cuticle. (Grapes also swell in water although the surface is covered with a coat of wax.) In my opinion, apart from the possibility of water uptake through the leaves, water discharge through the roots cannot be ruled out if the leaves are surrounded by an atmosphere saturated with water while the roots are in soil containing water only in a highly bound form. This, however, is of no practical importance.

UJVÁROSI, M.: Guttation is a physiological phenomenon in plants supplied with a normal amount of water. It is an irreversible process, the extent of which varies with the species.

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PÁL, GY.: If there is an evaporating or transpiring surface the humidity of the air increases parallel with its temperature. In air saturated with vapour there is no evaporation from water surfaces and the plants do not transpire because the air is unable to take up any more vapour; in most cases, however, the air is unsaturated. In your opinion with the same degree of vapour deficiency does an open water surface or a stomal surface of the same size show the more intensive evaporation?

ALMÁSI, T.: Without going deeply into the matter I think that an open water surface evaporates less water than a stomal surface of the same size.

ANTAL, E.: Evaporation always ties up energy. If the energy balances of the water surface and the plant surface are used as the starting point the following equations can be set up:

$$R_v = LE + Q_l + Q_v \tag{1}$$

$$R_n = LE + Q_l + Q_{ph} \tag{2}$$

Let us take the extreme case when thetotal available net radiation (R_v for the water surface and R_n for the plant surface) is spent on evaporation. In this case the sensible heat (Q_l), the heat fluxes for water and soil heating (Q_v and Q_t) and the value of the heat spent on photosynthesis (Q_{ph}) are zero. Let us express the evaporation (E_v) from the two equations and substitute the detailed values of the net radiation

$$R_v = G(l - A_v) - (K_v - V_l) \tag{3}$$

$$R_n = G(l - A_n) - (K_n - V_l) \tag{4}$$

The following correlation will then be obtained:

$$E_v = \frac{G(l - A_v) - (K_v - V_l)}{L} \tag{5}$$

and

$$E_n = \frac{G(l - A_n) - (K_n - V_l)}{L} \tag{6}$$

Here v represents the water surface and n the plant surface. If the water surface and the plant are near each other (e.g. within a few km), then the global incident radiation (G) has the same value. The albedo of water (A_v) is 5—10%, while that of the vegetation (A_n) is 25%. So $G(l - A_v)$ is always larger than $G(l - A_n)$, i.e. the water surface disposes of more radiation energy for the purpose of evaporation. The long-wave re-radiation of the atmosphere (V_l) is identical for both surfaces. The long-wave radiation of the plant surface (K_n) in the day hours is always higher than that of the water surface (K_n), since the plant surface is warmer. Consequently ($K_n - V_l$) is higher than ($K_v - V_l$). The latent heat (L) can be regarded as identical for the two surfaces. On the basis of the above it is perfectly clear that when whole fields are concerned, even if there is a full water supply, more warer evaporates from a water surface. This law of energetics cannot, however, be applied to a single plant removed from the stand (e.g. plants in culture pots), since in that case the advected heat increases the radiation energy and this extra amount of heat can also be used for evaporation. But the same applies to evaporimeters placed in the open. The smaller the vessel the larger the amount of advected heat and consequently the extent of evaporation. From a vessel exposed in this way many times as much water as leaves a natural water surface may evaporate.

The conclusion which can thus be drawn is that a larger amount of water always evaporates from a natural water surface than from a plant canopy with the same area.

BORKA, GY.: According to Stefan's law the intensity of evaporation is proportionate to the perimeter and not to the area (stomata). The area of the stomata makes up only a negligible proportion of the leaf surface, yet the extent of transpiration is occasionally 10—50% (sometimes even 100%) of the extent of evaporation from a water surface of the same size as the leaf surface.

BUDAVÁRI, K.: Transpiration through the stomata depends not only on vapour deficiency but also on temperature:

— at lower air temperatures (in the morning and afternoon hours) the transpiration values (T) are similar to those of evaporation (E), since the stomata are fully open at that time,

— the stomata begin to close at a temperature which varies with the plant variety, so "T" becomes constant at a maximum value characteristic of the plant, while the value of "E" continues to increase with the temperature.

Frenyó, V.: The question is not phrased exactly enough by asking whether "an open water surface or a stomal surface of the same size shows the more intensive evaporation". Presumably this should read, whether a surface equal in size to the open water surface and supplied with stomata evaporates more water or not.

It is, of course, possible to make a perforated lid which hardly obstructs the evaporation of the liquid in the vessel while protecting it from external contamination, but this could only increase the evaporation compared to the open liquid surface if thorn-like extensions protruded from the perforated lid, in which case it would be a matter of enlarging the surface.

Returning to the question, it can be said of this imaginary model that the transpiration of the leaves of some plants may approach, but will never exceed the evaporation of an open water surface of the same size. However, the very fact, that it may approach this value is surprising in itself, since the total area of the stomal openings is only a fraction of the leaf surface.

The phenomenon can be explained on the basis of Stefan's law. Accordingly, evaporation from small surfaces is proportionate to the radius or perimeter, and not to the area of the surface. This is perfectly understandable if we consider that the atmosphere above a larger surface soon becomes saturated by vapour which hinders any further vapour from passing over to the atmosphere. At the order of magnitude of a square micron, however, the rim effect is strong, or even dominant. The stomata on the leaf surface are at such a distance from one another (even if this can only be measured in microns) that they do not hinder each other's sideways transpiration. So, all in all a high transpiration value is obtained.

In the case of closed stomata a sharp reduction in transpiration was naturally observed, from which the conclusion was drawn that any narrowing of the stomata would necessarily decrease the water loss of the plants. It has actually turned out that a 50 or even 75% decrease in the stomal diameter causes no substantial change in the intensity of transpiration. Through a narrow opening the vapour departs at a higher speed; in addition, the so-called cuticular transpiration slightly increases. A ten-fold decrease in the diameter of the stoma is required to reduce the transpiration by about fifty per cent. Thus, the degree to which the stoma is open is not in direct proportion to the intensity of transpiration.

Füri, J.: I think that the transpiration of a plant exceeds the evaporation of a water surface, because if the atmosphere above an open water surface is saturated with vapour the evaporation will certainly "stagnate"; the plant, on the other hand, uses energy for its development (growth, fruit production), and requires water primarily to generate energy. The water is taken up mainly through the roots, though the plant is able to absorb water through the leaves as well. The continuous water uptake and energy production are coupled with respiration and water discharge, thus in the life of the plant transpiration is uninterrupted. The extent of transpiration is, of course, closely related with the growth vigour and production capacity of the plant, as well as with the humidity, air motion and temperature in the surrounding atmosphere.

Greguss, P.: This question is closely related to the phenomenon of transpiration. Transpiration is basically a biophysical process, as it is part of the life function of living organisms. Life cannot exist without water. Since water is of such vital importance, in the course of their ontogeny plants have always found a way of taking up, utilizing and discharging it. Special organs have developed in the plants for this many-sided activity. Some of them only take up water, others do the work of processing, while yet others are concerned with the expulsion or retention of water. The activity of the stomata is assured by their peculiar situation and structure; they automatically close or open as a response to light, temperature, changes in the turgor pressure or an abundance of water. There are a very large number of them, possibly exceeding 100 stomata/mm^2. At the same time they only occupy 1–2% of the total leaf surface.

Their mysterious role in transpiration has been clarified on a physical basis. The relevant experimental models show that membranes such as the epidermis cell-walls, in which the tiny openings are at a certain distance from one another, function according to a very important physical law. Investigations nave proved that the diffusion of gases, and thus of water vapour, through the pores depends on the diameter ($2r\pi$) or perimeter of the openings and not on their area ($2r\pi$).

If two circular openings of different size are compared, one with a radius of 2, i.e. its surface area is 4π, and the other with a radius of 1, i.e. its surface area is 1π, the amount of water evaporating through the larger opening is not four times, but only twice as much as that departing through the smaller opening, since the ratio of the diameters is $4 : 2 = 2 : 1$. Looking at the phenomenon the other way round it is found that through 4 small openings of the same size, with a total area equal to that of the large opening, not the same amount but twice as much gas (vapour) will diffuse. The physical explanation is the following. The stomata, which as a rule are spaced at a distance of 10 stomal openings from one another, can be regarded as tiny chimneys, from which the vapour molecules depart not only perpendicularly but also freely sideways. From the perimeters of many pores a lot more vapour molecules can depart freely, because the molecular chains, which bend outwards at the edges of the pores, are not hindered by neighbouring molecular chains, whereas over a large water surface the molecules mostly depart vertically and their velocity is checked by the neighbouring molecules. On the basis of this physical law it can be established that through a membrane perforated by tiny holes, such as the stomal cell-walls, more gas will pass in the same period of time and at the same pressure than through a single opening with an area equal to the total area of the holes (pores). Thus, the velocity of diffusion is proportional to the diameter or perimeter ($2r\pi$) and not to the area ($r^2\pi$) of the openings. This provides an answer to the question.

The intensity of evaporation (transpiration) may, however, be considerably influenced by external factors, as well as by the position of the stomata. In an environment with high percentage humidity the stomal openings generally protrude from the epidermis (hygrophyte plants), while in the desert they sink deep in it (xerophyte plants). Under normal conditions, however, they are placed at the level of the epidermis (mesophytes). In the tropics, e.g. in the humid jungles, where the environment is saturated with vapour, the plants expel their surp us water through the stomata or hydatodes, and there are also plants (Colocasia) which discharge the superfluous water in the form of drops.

The cuticle which covers the leaf also plays a part in transpiration. This was previously thought to be a continuous surface without pores, but recent studies on its fine structure have revealed tiny pores in it. On withering, cracks occur in the cuticle, through which the vapour can depart (cuticular transpiration) or be absorbed. This amount of water is, however, 10—12 times less than that released through the stomata (stomal transpiration).

GYENGE, J.: I have frequently had the opportunity to observe that over a smooth water surface the vapour seems to hover, while the same phenomenon is never seen in a field of maize, sugar-beet, etc., probably because in the closed plant stand the vapour at once precipitates. It can also be imagined that the water discharged by the stoma is physiologically bound, but that it regulates the amount transpired, while the water evaporating from a water surface is only molecularly bound, though this contradicts the fact that a stoma surface of physically the same size covers a larger effective surface than a smooth sheet of water, and logically this means that the water discharging capacity of the stomata is higher.

Therefore, in my opinion, a distinction should be made between evaporating capacity and actual evaporation adapted to the conditions.

HORVÁTH, I.: The vapour content referred to in the first sentence is absolute vapour content, and this has no direct effect on the transpiration. The vapour mentioned in the second sentence, on the other hand, is relative vapour content; if this is 100%, i.e. the air is saturated, the physical conditions for transpiration do not exist. The second part of the question stands in need of correction. The total area of the stomata is generally about 1% of the leaf area; in spite of this the amount of water discharged through transpiration is nearly equal to that evaporated from an open water surface of the same size as the leaf area. This is the so-called relative transpiration, the value of which may reach 0.9 (from an open water surface it is 1).

This phenomenon can be explained by the so-called Stefan rule which describes the evaporation of small surfaces (of the order of a suzare micron). The answer to the question in its original formulation is thus: the total stomal surface discharges an amount of water larger by about two orders of magnitude that that evaporated by an open water surface of the same size.

KISS, A. S.: The amount of water evaporated from an open water surface is smaller than that transpired from a stomal surface of the same total area. The smaller and more widely spaced the stomata are, the greater the difference. Stefan's law holds true for the vapour diffused through the stomata. This law states that evaporation through small pores is proportional to the perimeter and not to the area of the pore. Thus, a large number of scattered small stomata evaporate more water than an open water surface with the same area. This can be explained by the fact that evaporation is more intensive at the edges of the pores where the water molecules hinder each other less in leaving the surface and entering the atmosphere. When the small pores are more widely spaced, evaporation will be more intensive for the same number of pores because the humidity of the atmosphere is lower and in the vapour phase the water molecules cause less hindrance to each other's movements.

LELLEY, J.: I have no knowledge of experiments designed to compare evaporation from a water surface with transpiration through the total surface of the stomata. However, on a purely speculative basis I should think that transpiration through the stomata might be more intensive than evaporation from a smooth water surface, since in the former case an active biological process is taking place.

LŐRINCZ, J.: With the same degree of vapour deficiency in the atmosphere a larger amount of water will evaporate from an open water surface than through the stomata of the leaves, since in this case the stomata close up to reduce transpiration.

MIHÁLYFALVY, I.: Under the same conditions of air humidity the evaporation of an open water surface has been found to be more intensive than the transpiration of a leaf surface of the same size in the plant species examined. In a plant stand where the leaf area is three or five times as large as the soil surface, the total water discharge (ET) may occasionally attain or even exceed the extent of evaporation from an open water surface.

Under the conditions in Hungary, evaporation from an open water surface from October to March is about 0.5—2.5 mm a day, while from April to September it ranges between 3 and 5 mm a day. The extent of evapotranspiration shows a great fluctuation from year to year. The trend depends to a great deal on climatic factors and on biological and production conditions, in other words, on the factors which primarily influence transpiration in the individual plants.

PÁSZTOR, K.: Transpiration through the stomal surface is higher than evaporation from an open water surface of the same size, since the observations made so far show that diffusion through the stomata is not in proportion with their small surface. This type of comparison is not advisable in my opinion, because a physical process is being compared with a biological one.

PETRASOVITS, I.: In our investigations it was chiefly the transpiration of leaves of different ages, rather than that of stomal surfaces, that was compared to the potential evaporation — which within certain limits can be considered identical with the "evaporation of an open water surface" as formulated in the question.

In Fig. 1 the transpiration of differently aged leaf surfaces of non-irrigated sugar-beet and maize are compared to one another and to the potential evaporation of the atmosphere. From the numerous quantitative correlations in the figure it is clear that the transpiration of a unit leaf surface is always less than the evaporation from a unit area of open water surface. If this is not so, then the methodological circumstances must be closely examined. It is, in fact, physically possible for the depth and breadth of the "open water surface", its position below or above the ground level, and the quantity and quality of materials dissolved or floating in the water to modify the flow of light and heat and the process of evaporation.

When comparing the average leaf transpiration to the potential evaporation by taking the water content of the air or the soil into consideration rather than the age of the leaf, measurements in potato and sugar-beet stands gave the correlations in Fig. 2.

My answer to the question on the basis of the data in the figure is: with a favourable water supply the transpiration of a unit leaf surface comes close to but never reaches the amount of potential evaporation.

The stomal surface is also mentioned in the question. The so-called relative transpiration, usually expressed as the ratio of transpiration (T) to potential evaporation (E_p) : T/E_p, has been examined.

Figure 3 shows the data obtained in irrigated and non-irrigated sugar-beet stands.

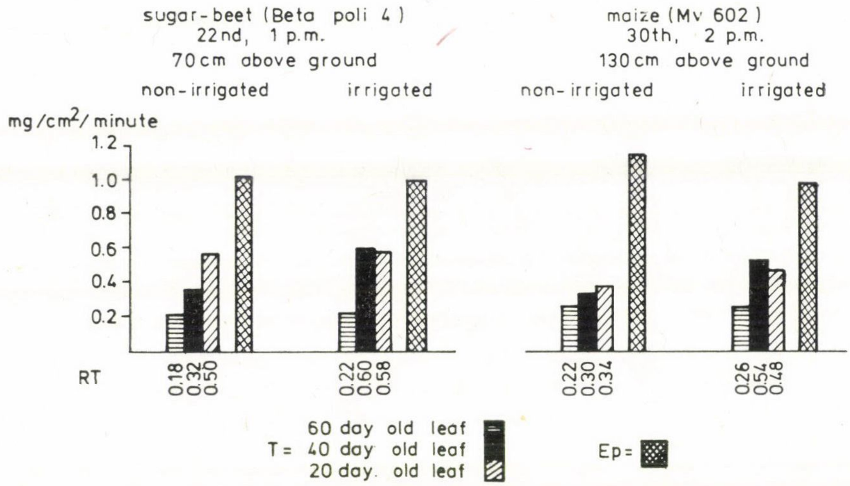

Fig. 1. The transpiration intensity of leaf surfaces (T) in leaves of different age, and the potential evapotranspiration of the stand (Bp.). Gödöllő, July 1969

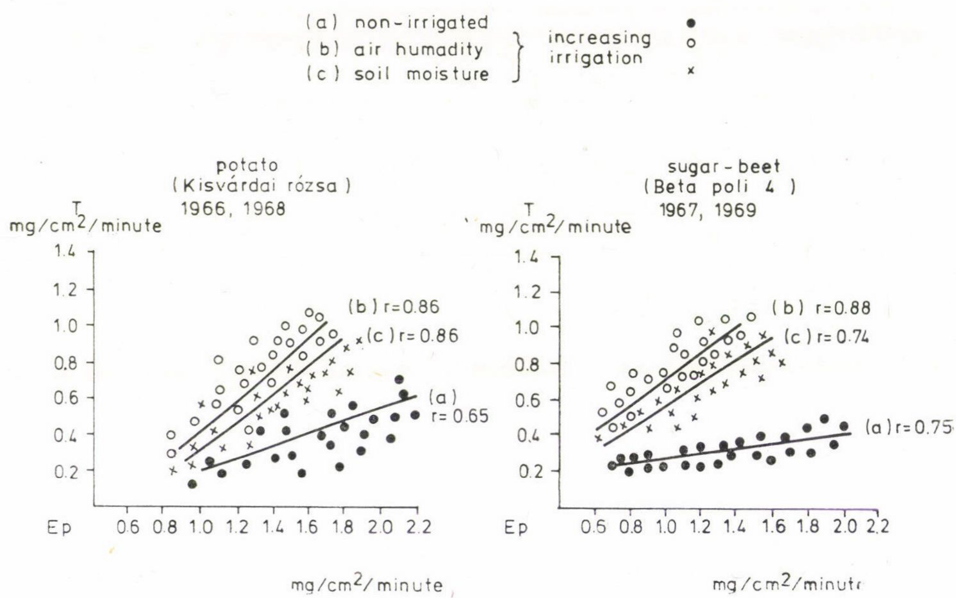

Fig. 2. Relationship between potential evaporation and leaf transpiration at 50 cm stand level. Gödöllő

It can be unequivocally established that higher relative transpiration is associated with more pronounced opening of the stomata, especially in the irrigated stand. This leads to an important practical conclusion. Irrigation in general, and "atmospheric" irrigation in particular, helps to overcome the following bioecological contradiction.

At noon on days with typical weather conditions there is abundant light energy, but at the same time, partly because of the increased water loss from the leaves, the stomal openings narrow, thus reducing the inflow of CO_2 to the sites of photosynthesis.

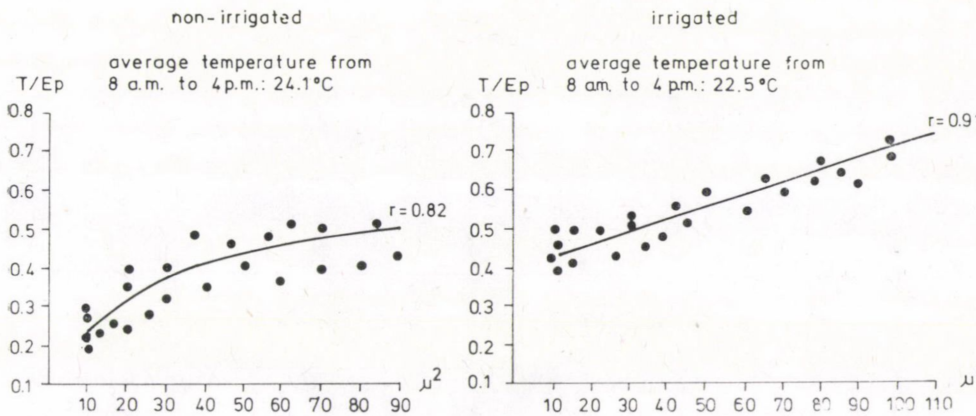

Fig. 3. Relative transpiration and average size of stomata on the upper leaf surface of sugar-beet (Béta poli) at a height of 70 cm above ground level, on the basis of data obtained between 2 a.m. and 12 midnight. Gödöllő, 5th August 1965

Thus, while there is an abundance of energy for assimilation, the amounts of water and CO_2 may be restricted. The value of relative transpiration is an important indicator of this phenomenon.

PLETSER, J.: With the same extent of saturation shortage, evaporation will be more intensive on a surface with a higher temperature, surrounded by brisker air currents. Evaporation by an open water surface is also determined by its temperature and the velocity of the air moving above it. The transpiration of leaves is directed by the air temperature, humidity, radiation and wind velocity, though the opening and closing of the stomata also have some influence on it. If there is enough water in the soil and the other environmental conditions are also favourable for transpiration, then the amount of water emitted by the plant may be more than that evaporated by a water surface of the same size.

POZSÁR, B.: The leaves are able to excrete drops of water at the edges or tips of the leaves not only in the case of a minimum deficiency of saturation but also when the deficiency is considerable. This excretion of water is an active process presumably related with the cell respiration. The active water discharge is so fast that the water cannot become vaporized immediately even in the case of low relative humidity. This proves that the transpiration of plants is more intense than the evaporation from water surfaces of the same size.

SOMOS, A.: Without really knowing, I would assume that the amount of water transpired by the leaf would be larger than that evaporated from an open water surface, since in the former case the water is discharged under a certain pressure (at the root-neck), though it might be dependent on the intensity of radiation and the temperature of the soil in the root zone as well.

SZABÓ, L. GY.: The transpiration capacity of the stoma depends not only on the relative or absolute humidity of the air but also on the light intensity. The degree of humidity is also important. It is a well-known fact that much less water is transpired by an intact leaf than is evaporated by a water surface of the same size. The stoma is so much a functional structure that a mechanical comparison is not realistic.

SZALAI, I.: The speed of vapour diffusion through the stomata is considerably higher than would be expected from the ratio of total stomal area to the total leaf surface. Each stoma can be regarded as an extremely small evaporator. Evaporation from such a small surface is proportional to the diameter (perimeter) and not to the area. This seemingly paradox phenomenon can be explained by the greater speed of diffusion along the walls of the vessel compared with its centre, due to the quicker dispersion of diffunding particles in space. The molecules in the centre depart parallel with the longitudinal axis of the stoma, while those at the edges deviate from the axis (Fig. 1).

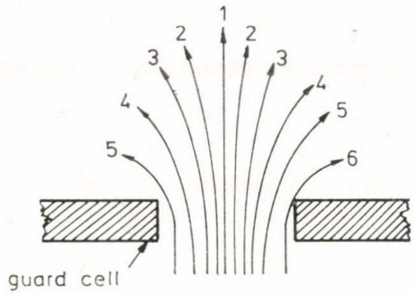

Fig. 1. Dispersion in the air of vapour molecules departing through the stoma

The extent of this peculiar vapour diffusion depends on the relative proportions of the circumference and the area. It can easily be shown that the circumference becomes proportionately larger in the case of a large number of small pores as opposed to a small number of large pores giving the same surface area.

For example, let us suppose that the area of each of ten small pores is a cm^2, and that of a large pore $10a$ cm^2, while their radii are r and R cm, respectively.

In this case

$r = \sqrt{\frac{a}{\pi}}$, so the circumference of the small pore $= 2\pi\sqrt{\frac{a}{\pi}}$ and the total circumference of the ten small pores $= 20\pi\sqrt{\frac{a}{\pi}}$,

$R = \sqrt{\frac{10a}{\pi}}$, so the circumference of the large pore $= 2\pi\sqrt{\frac{10a}{\pi}}$.

If the equations are put into the standard form and reduced, the ratio of the two circumferences will be:

$$\frac{\text{circumference of 10 small pores}}{\text{circumference of 1 large pore}} = \frac{10\sqrt{a}}{\sqrt{10a}} \simeq 3.$$

The increasing effect of the edge of the pore depends on the distance between the stomata. If the distance between them is less than ten times their diameter, the molecules diffusing from the edge of one pore will meet molecules diffusing from the edge of another pore, thus impeding each other.

When the pore opens, the water molecules coming out form a series of diffusion "shells" and at the same time a diffuse gradient (Fig. 2).

If the external partial pressure of the vapour is P_e, and the pressure in the opening of the stoma is P_d, at a point immediately outside the pore the pressure will be intermediate between P_d and P_e. Hence, in the "diffusion shells" a series of partial pressures (diffusion gradient) develops:

$$P_d > P_1 > P_2 > P_3 > P_4 > P_e$$

which are indicated in the figure by contour lines.

To sum up: through many tiny pores (stomata) a larger amount of vapour departs in unit time than from an open water surface equal in size to the total area of the pores. As regards the leaf this means that the stomata make up only 2% of the surface area of a given leaf (of 1 dm^2 in size, for example), and this 2% stomal surface is able to transpire about 60% of the amount of water evaporating from an open water surface of 1 dm². The ratio of the two is expressed by the *T/E* quotient, which in the case of mesophytes generally corresponds to 60%.

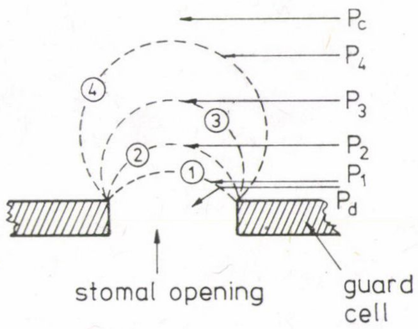

Fig. 2. Position of a relatively mitionless "air-cushion" over the stomal opening

SZALÓKI, S.: However developed the stand is, cultivated plants never possess as large a stomal surface as their growing space, i.e. the surface of the soil. In spite of this it can happen that the amount of water transpired by the plant stand is as great, or even greater than that evaporating from an open water surface of the same size. There may be several reasons for this.

Evaporation from a water surface and transpiration by a plant stand well supplied with water are generally only restricted by the amount of energy available and the condition of the vapour uptake system. There is, however, a difference between the heat regime of water and that of a plant stand even if the albedo of each is nearly identical.

This is because the dynamics of the absorption and emission of radiant heat and the uptake of advective energy are different in the two cases. I have found, for instance, that advective heat (carried by the movement of the air) is taken up more easily by plants than by water.

VARGA, M.: Since transpiration is, in fact, evaporation from a special surface, all the factors which act on evaporation also influence the process of transpiration in the same way. Of these factors the relative humidity of the air is the most decisive. With the same degree of vapour shortage in the air, if the other external factors are uniform, vapour diffusion through the stomate and from an open water surface of the same size (if it is possible to imagine one with such a microscopic size) should thus be identical.

However, when comparing vapour diffusion from an actual water surface many times larger than the stomata to that from the numerous tiny stomata on the leaf surface, the situation may be very different. The extent of evaporation over a separation wall from the surfaces of tiny pores set at a certain distance from one another is, due to the possibility of side diffusion, proportional to the diameter, i.e. perimeter, of the pore rather than with its area. Thus, in consequence of the considerable side diffusion from the edges of the pores more vapour can depart through a large number of small openings in a unit time than would be expected from their total area.

A leaf surface perforated with stomata can be regarded as a multipored separation wall. Although the stomata only make up 1—2% of the leaf surface even when they are fully open, the amount of water departing through the stomata can be surprisingly large compared to the size of the leaf. Some experts think that vapour diffusion through the stomata can take place at the same speed as from an open water surface, as if the leaf had no epidermis; or the stomata together may even be able to discharge more water than an open water surface equal to their total area (SZALAI, I. (1974): Növényélettan I—II. (Plant physiology I—II). Tankönyvkiadó, Budapest]. Others consider that the amount of water discharged through the stomata can be up to 50% of that evaporating from a water surface equal in size to the leaf surface

[CSEH, E. (1976): Vízforgalom (Water metabolism). Az ELTE Növényélettani Tanszék egyetemi jegyzete (ed.: Láng, F.), chapter I. Budapest], which is still a surprisingly high value.

This difference of opinion is quite natural if we consider that, apart from the factors mentioned so far, numerous other factors also influence the relation between these two values. If the relative humidity is constant the extent of transpiration through the stomata depends on the following highly varying conditions: *a)* number of stomata per unit leaf surface, *b)* distance between the stomata, since there is a higher possibility of side diffusion if they are further apart, *c)* the air motion which determines the rate of side diffusion, and *d)* size of stomata (i.e. the extent to which they are opened) which gives the ratio of perimeter to surface area. The extent to which the stomata are opened is, in turn, determined by many further factors: light intensity, CO_2 concentration, temperature and water content of the guard cells. These factors act in a complex manner on the opening and closing of the stomata; in addition, the endogenous daily rhythm of the stomal motion must also be taken into account.

I think it follows from the above that it cannot be categorically stated whether or not the amount of water departing through the total surface of the stomata is larger than that evaporating from an open water surface of the same size under identical humidity conditions, because the ratio of the two values may vary greatly depending on the circumstances. The only thing that is obvious and can be unequivocally stated is that the amount of water departing through the stomata is many times more than the ratio of the total surface area of the stomata to the size of the leaf surface.

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PÁL, GY.: **Under dry farming conditions the plants are spaced more widely than would be necessary to ensure light for them; in this case the spacing is determined by the water level of the soil, while in irrigation farming it is determined by the light demand of the plant. Do you think that the larger yields obtained with irrigated crops are due to the higher plant number per unit area or to the higher productivity of the individual plants?**

ALMÁSI, T.: The optimization of irrigation and plant number has been analysed in many years of experiments. Sometimes a wider spacing is used to accelerate the propagation of breeding material from a thickly sown crop, in order to be able to increase the yield due to the better light, heat, water and nutrient supply associated with a somewhat lower number of plants per unit area. This increase naturally has biological limits. Wide practical experience proves that stand density also has its cardinal points (minimum, optimum, maximum), which must be strictly observed in the interests of production. If the conditions required for skilfully applied irrigation are provided, an attempt can be made to develop an optimum plant stand fully utilizing the harmony between the factors; this will be a better guarantee for a surplus yield than trying to create superintensive conditions in "wide spacing". Besides human will an objective precondition for fulfilling the task is, for example, the availability of suitable machinery for sowing.

ANTAL, E.: If the same number of plants per unit area are grown under dry and irrigated conditions the individual plants produce larger yields in the latter case, because more water is required for the utilization of the photosynthetically active radiation, in addition to which more nutrient is available in an irrigated field. To study the question evapotranspirometer experiments were carried out on Mv-1 hybrid maize provided with optimum water and nutrient supplies and sown to five different stand densities. The water and nutrient supplies and the variety were identical for years in all the treatments, with only the weather changing from year to year. The optimum stand density could not be established unambiguously, as it changed from year to year as a function of the sunshine hours and the temperature. In years with low temperatures and less sunshine hours a maximum yield was obtained with a less dense stand, while in warm sunny years a denser stand gave the maximum yield. Thus, no rule can be given as to the stand density best suited for irrigation farming, since it depends on the weather. Unfortunately, the weather conditions during the growth season cannot as yet be foretold at the time of sowing.

ÁCS, A.: A short answer can be given to this question. Larger yields are due primarily to the higher individual number, while a possible surplus yield per plant as a result of irrigation is a secondary effect. Of course, if the spacing between the plants is relatively wider the surplus yield of the plants will be the primary factor, e.g. in thin sugar-beet stands, or when widely spaced maize plants produce two ears each.

Borka, Gy.: In Hungary the utilization of nutrient is often limited by the unfavourable water conditions. Irrigation enhances the availability and incorporation (utilization) of nutrients, thus providing the conditions under which the genetically determined production potential of the plant can be achieved.

Budavári, K.: If irrigation farming is properly carried out (right variety, plant number, nutrient and water supply, etc.) yield surpluses are due both to the increased plant number and to the higher individual productivity.

Debreczeni, B.: The primary role of the different agrotechnical procedures (fertilization, irrigation, soil cultivation) is to improve the water and nutrient supply of the plants. On the other hand, plant number (spacing) and variety are production factors which are able to make better use of these improvements in the soil. In multifactorial experiments carried out with maize (variety Mv-1) in recent years the interactions between irrigation, fertilization and plant number were studied on a calciferous brown forest soil (see table below).

Grain yield of maize on a 5 year average, q/ha

Plant, number/ha	Treatment	Fertilizer active agent, NPK kg/ha		
		0	200	300
33,700	non-irrigated	54.8	71.5	70.0
	irrigated	59.2	77.7	81.0
43,300	non-irrigated	55.8	75.6	73.5
	irrigated	60.3	81.3	86.2
53,300	non-irrigated	56.2	75.2	75.6
	irrigated	60.0	80.7	83.5

The data show that for the given maize variety an increase in plant number resulted in favourable effects up to 43,000/ha, i.e. up to a spacing of 2310 cm^2, even under intensive growing conditions (irrigation, fertilization). At the same time, the effect of irrigation was enhanced by fertilizers rather than by the plant number, while the effect of fertilization was more dependent on plant number and irrigation. In my opinion, in the case of irrigated crop production, larger yields are primarily the consequence of a higher plant number per unit area, particularly when the higher nutrient requirement this involves is satisfied.

Frenyó, V.: Properly applied irrigation naturally increases the yields compared to the system of dry farming; otherwise it would not be worth carrying out irrigation. In this context the question is whether the increased yield is due to the higher stand density or to the larger individual production of the plants.

In the ideal case the two causes play a joint role in the increase in yield; this naturally requires a higher rate of fertilization (nutrient supply) too. If the irrigated field produces more than the non-irrigated one in spite of a deficient mineral supply, then the result is probably due to the larger individual number, ignoring for the moment the possibility that irrigation may also promote better nutrient uptake from the soil.

Füri, J.: In the case of perennial crops there is not, in my opinion, any close correlation between the yield and the number of plants per unit area. Thus the yield of grapes can be increased by improving the production potential of the plant. With ridge cultivation, a method previously used for training vines, an insufficient water and nutrient supply resulted in lower yields if 8—10 thousand vines were planted on a hectare. Today, on the other hand, with an optimum water and nutrient supply to 2000—3000 vines/ha and an optimum fruit load the yield per unit area can be substantially increased. It is thus by increasing the biological potential of the plant that large yields can best be obtained.

GYENGE, J.: Irrigation farming requires special varieties, and the optimum amount of water for the potential productivity of the variety must be determined.

In the current varieties large yields are undoubtedly due to the higher number of plants per unit area, because these varieties were bred for a normal water supply and at present the aim is to ensure this level by means of irrigation on areas poor in precipitation.

Individual production is a genetically determined character of the plant; at the same spacing different varieties produce different yields both indificually and as a stand.

Varieties bred especially for irrigation are expected, among other things, to give a larger yield per plant and a higher number of plants per ha, because there seems to be a contradiction at this point in the old varieties.

HARMATI, I.: The large yields obtained as a result of irrigation vary with species and varieties. In the case of cereals they are influenced by the date of irrigation as well.

In wheat irrigation before sowing results in the rapid, 100% germination of the seed, thus increasing the plant number compared to non-irrigated wheat stands. Irrigation in April promotes productive tillering and may increase the number of grains per spike, while in May only the thousand-grain-weight can be increased by means of irrigation. Yield surpluses in irrigated wheat growing are primarily caused by the higher productivity of the individual plants, due mostly to the increased productive tillering and to a lesser extent and less frequently to the larger weight of the ear.

The surplus yield obtained by irrigation in maize can be attributed partly to the increased productivity of the individual plants and partly to the larger plant number (about ten thousand per ha more) used in irrigation farming. This is supported by the following data.

In the case of grasses and alfalfa surplus yields are due to more intensive tillering and growth and to better sprouting; in other words, to higher productivity per plant.

Grain yield per plant (1976) in g

Hybrid	Non-irrigated	Irrigated	
	50,000 plants per ha		60,000 plants per ha
SzTC 255	151.8	172.8	163.8
KSC 360	152.9	189.6	173.1
Sze SC 444	219.9	253.6	225.7
Sze TC 505	201.1	255.2	224.0
BCSK 66-25	193.6	226.4	202.9
SzeMSC 606	197.6	241.6	213.9

Grain yield surpluses (q/ha) obtained with irrigation as a function of plant number (three-year averages of 3 hybrids)

Water regime in the soil	40	50	60	70	80
	thousand plants per ha				
Poor	15.0	17.3	18.8	19.7	20.2
Good	8.0	9.8	11.1	12.3	13.3
Average	11.5	13.5	14.9	16.0	16.7

Horváth, I.: The statements made in the first half of the question can be disputed and are not even related with the problem raised at the end. As to the latter, the reduction of spacing beyond a certain limit, i.e. high stand density, decreases the individual production, but within a given limit the total yield will be larger because of the higher plant number. (Concrete figures for the stand density cannot be given as it depends on specific and varietal properties.) Increasing the stand density, which is allowed among other things by a better water supply, is an important way of obtaining larger yields. It can only be used, however, when the individual plant size in the crop concerned is a negligible factor, and only the total yield is important.

For the sake of completeness, it should be mentioned here that stand density is only related with the light conditions in so far as the upper limit is determined by the mutual shading of the individual plants and by the light requirement of the crop. The total light energy does not represent a limiting factor, since under field conditions the photosynthetic energy utilization does not exceed 5–6% even in the case of highly intensive farming.

Kiss, A. S.: In the case of irrigation the number of plants per ha can be increased, but the resulting increase in yield will be due not only to this but also to the higher number of yield components per plant. In soybean the increase in the number of pods and in the number of seeds per pod (a 40% increase in the latter over the average of five varieties) has been found to depend on the variety. In the wheat variety Kavkaz the ear length has shown a 12% increase as a response to irrigation, resulting in 10% more spikelets and 16% more grains per ear. In the case of maize the number of ears per plant (i.e. the number of plants with two ears), the weight of the ear and the thousand-grain-weight have been found to increase. This can be explained by the fact that the number of yield components increases with the better nutrient supply that irrigation ensures. The efficiency of irrigation depends on (increases with) the stand density too. For example, with the maize variety SzTC 255 irrigation has resulted in a yield surplus of 8 q/ha when the plant number is 40,000/ha, and 19 q/ha with a plant number of 80,000/ha. This is quite understandable, since with a higher number of plants on a non-irrigated area water will increasingly become a limiting factor.

Kovács, G.: In the case of dry farming a smaller number of plants per unit area should be reckoned with than on areas well supplied with nutrients and water. In a similar way, on soil with low fertility a lower number of plants per unit area is required than on areas abundantly supplied with nutrients. In the early sixties the trend of maize yields was followed under irrigated and dry conditions with the maize hybrid Martonvásári 5 as the test plant. With the same spacing (70×40 cm) statistically significant surplus yield due to irrigation could not be demonstrated, though the irrigated stand was better looking. The stalks were longer and the stalks and ears were thicker, but no essential difference in grain yield was found. With an increasing plant number the grain yield substantially increased, so, considering the results of this and many subsequent experiments, I am convinced that in irrigated crop production the higher number of plants per unit area is more important than the larger yield per plant. It is the same in the case of silage maize, where the green crop or the absolute dry matter production is taken into consideration; the individual plants in equally thin stands give larger yields. Furthermore, under the influence of irrigation alfalfa stands sown with the same plant number ensure a good yield by more productive tillering and increased plant height. While in dry farming water is the decisive factor in vegetative development, in sugar-beet and potato an increase in plant number rather than a larger individual yield is the guarantee of a surplus yield due to irrigation. In the case of wheat, if storage irrigation is supplied in autumn on soils with deep ground-water but good water retention, followed by early spring irrigation, tillering will be more intensive and the number of ears per unit area and the number of grains per spikelet will increase.

Lelley, J.: There is an inverse relation between plant number and individual productivity even under irrigated conditions. It depends on the species and variety to what extent the two participate in producing a yield surplus. It is undoubtedly most fortunate from a genetic point of view if the two components are balanced and both have a share in the yield surplus within the limits of genetic determination. If either of the components dominates at the expense of the other an optimum realization of the hereditary yield potential is no longer possible.

LŐRINCZ, J.: In irrigated crop production higher yields are undoubtedly due both to the larger or near optimum plant number and to the higher individual productivity of the plants. An excessive increase in the plant number would naturally reduce the yield per plant, though the total yield might further increase for a while.

MIHÁLYFALVY, I.: The yield of plant stands is to some extent determined by the size of the leaf surface per unit area, which is related with water consumption. In the case of a lower number of plants per unit area (larger growing space) it is higher individual production that has a decisive effect on the total yield, while with an optimum or above optimum plant number it is the larger number of plants per unit area.

In irrigated maize the grain yield was found to increase up to a plant number of 50—55 thousand/ha, while with a higher plant number the grain yield decreased owing to the lower shelling ratio. Thus, the increased leaf cover associated with higher plant number inevitably causes a shortage of light.

NÉMETH, S.: In the case of plants grown with the same spacing under dry and irrigated conditions, the yield surplus obtained as a response to irrigation will be due to the larger yields of the individual plants. Making use of the good water conditions (and nutrient supply) on irrigated areas, in a number of crops it would be better to space plants closer than is usual in dry farming. Although, up to a certain limiting density the individual production of the plants does not increase in such cases, it does not decrease either, at least not to a great extent, and the yield surplus produced by irrigation will be due to the higher number of plants per unit area.

PÁSZTOR, K.: The question is somewhat too general. It is not only the water content of the soil but also the position of the leaves that determines the spacing of a crop. It is known, for instance, that in a too densely sown maize stand many plants will become sterile. Even under irrigated conditions the plant number can only be increased to such an extent that etiolation and sterility of the plants is not caused. For this purpose breeding aims should include the production of short-strawed (120—130 cm) hybrids with upright leaves above the ears or with ears growing closer to the tassels. Such hybrids render it possible to raise 100,000 plants per ha, whereby the solar energy is better exploited. Another breeding objective might be the production of bushy hybrids of medium height with a larger number of ears, of which 50—60,000 plants per ha could be grown.

Naturally, other breeding solutions may also be found. Whatever the tendency in breeding, stalk strength, resistance to pests and pathogens, and a favourable response to irrigation and nutrition are fundamental requirements for plant varieties grown under irrigated conditions.

PETRASOVITS, I.: In irrigated crop production the higher individual productivity of the plant also plays a role in attaining larger yields. Compared to dry farming conditions, however, the higher number of plants per unit area is a more important factor, depending on the crop, since the productivity of photosynthesis depends on the variety as well as on the age of the leaves. Under irrigated conditions the proportion of young leaves is larger and the rate of senescence is slower. The yield-increasing effect of this phenomenon is well utilized in practice by a larger — though not too large — number of plants per unit area. A disadvantage of the phenomenon may be the undesirable prolongation of vegetation, but the danger of this can be lessened by a harmonious water and nutrient supply.

PLETSER, J.: In irrigated crop production individual plants give larger yields than under dry farming conditions. Apart from the light requirements of the plants, spacing may be determined by agrotechnical reasons as well. A larger number of plants per unit area also increases the yield. Nutrient replacement and irrigation must naturally be adjusted to the spacing of the plants.

POSGAY, E.: When the plant number (spacing) is identical larger yields per unit area are always due to the higher productivity of the individual plants. If, for example, the water supply is reduced to less than optimum, individual production, and thus the total production of the area, will decrease.

The amount of water available on a given area limits the amount of yield. The number of plants with which the optimum utilization of the available water can be achieved depends on the species, variety, etc. In the case of sugar-beet, for example, in a dry year under irrigated conditions a larger plant number and higher individual weight gave the maximum yield, while with a sharply reduced water supply a smaller plant number and lower individual production was required for a maximum yield.

Depending on the extent of water deficiency, it may happen that the non-irrigated crop gives a maximum yield with a lower plant number, but with an individual production equal to or larger than that of the irrigated crop. Thus, the higher plant number definitely plays a role in the larger yield of the irrigated crop, while the individual production in the non-irrigated crop is lower or higher, depending on the extent of water deficiency.

Pozsár, B.: On irrigated areas the average yield per plant is lower compared to dry farming, but owing to the larger number of individuals the yield per unit area is larger.

Shmilliár, M.: The amount of yield is a function of the number of plants per unit area under either dry or irrigated conditions. Loss of plant number beyond a certain limit cannot be substituted for by the individual growth of plants. With the same plant number the individual plants produce larger yields under irrigated conditions. According to experimental data on sugar-beet the higher the number of plants the larger the yield per unit area. Stand density is, however, limited by the fact that below a certain size sugar-beet cannot be processed with the present equipment. Therefore, an optimum plant number and size have been evolved which must be kept to with a minimum of deviation to obtain a satisfactory quantity and quality. This number ranges from 90 to 100 thousand plants per hectare.

The following data are from an experiment set up to determine the optimum plant stand.

Year	Spacing					
	37.5×20 cm			37.5×40 cm		
	root, q/ha	dig., %	sugar, q/ha	root, q/ha	dig., %	sugar, q/ha
1951	304.08	16.34	49.43	272.63	15.71	45.23
1952	515.41	16.50	84.60	449.37	15.79	70.86
1953	431.13	16.56	71.38	405.58	16.37	66.36

These data are confirmed by János Zana's experiment in 1961, where the spacing was 40×25 cm and 40×50 cm, respectively.

Yield	Thick stand, 40×25 cm	Thin stand, 40×50 cm
Root, q/ha	344.30	297.84
Dig., %	17.05	16.14
Sugar, q/ha	48.06	39.15

In the experiments the sugar content in the thin stand considerably decreased compared to the thick stand.

Spacing is determined by several factors: the amount of precipitation during the vegetation period (this is where irrigation is important); reduction of certain plant diseases; possibilities of mechanization in sugar-beet production, since this sets a limit to the reduction of row and plant distances. But apart from high yield averages and the mechanization aspect sugar-beet production must fully satisfy the demands of the sugar industry. In an experiment where the plants were spaced at 40×10 cm and the number of plants was 150,000/ha, the average weight was 160–180 g per plant, and though the yield was the largest of all in this experiment, the crop was not suitable for sugar production as regards either root or sugar content.

SOMOS, A.: Irrigated plants give larger individual yields than non-irrigated ones at the same spacing. Taking the optimum spacing for plants grown under dry conditions as a basis, the increased stand density results in a reduction in the individual yields of irrigated plants while the yield per unit area will grow, though the rate of growth shows a tendency to decrease. Beyond a certain limit of stand density, which is much higher than in the case of dry farming, the yields first stagnate and then decrease. Thus, in the case of identical or nearly identical spacing the larger individual yield is the decisive factor, while in a thick stand it is the higher number of plants per unit area. With high stand density the individual production of the irrigated plant may be much lower that of a plant grown in a thin stand under dry conditions.

SZABÓ, L. GY.: The larger yields obtained in irrigation farming are mostly due to increased individual production.

SZALAI, GY.: If more favourable ecological conditions are ensured the larger yield is due partly to the higher plant number per unit area and partly to the increased individual production, i.e. each of the two factors has a part in it. It must be noted, however, that increased stand density generally involved a reduction in the production of the individual plants. For example, in the winter wheat variety Jubileinaya 50, grown under farm conditions, the grain yield as a function of the number of ears showed the following trend over the average of several years:

Ear, no./m^2	Grain yield per ear, g	Grain yield, q/ha
300	1.13	33.9
400	1.01	42.6
500	1.00	50.0
600	0.93	56.0
700	0.87	60.8

It is worth increasing the number of plants per unit area as long as the percentage increase is higher than the percentage decrease in individual production. Once these two changes are of equal value the plant number must not be increased further, as it would result in a reduction in yield per unit area.

This does not, of course, mean that a given crop produces a larger yield as a response to irrigation merely because of a higher number of plants. In consequence of the more favourable conditions provided by irrigation the plants produce larger individual yields (with the same plant number per unit area) than they do when there is a water deficiency. Here again, distinctions must be made. For example, well-established maize and sugar-beet stands give larger yields as a response to irrigation mainly through the increased production of the individual plants. At the same time, in dry springs starter irrigation may ensure vigorous growth and a closed stand, without which large yields cannot be obtained. Hence, I must again emphasize that under Hungarian conditions irrigation makes it possible to increase the stand density, and occasionally increases the individual production of the plants as well.

SZALÓKI, S.: With increasing stand density the productivity of individual plants decreases even under irrigated conditions, but the total yield will increase up to a certain limit.

The optimum plant number from the point of view of the quantity and quality of economically useful produce (product) is generally smaller than the optimum for dry matter formation, i.e. for the utilization of light.

In irrigated crops it is easier to determine the most favourable plant number and the amount of yield per plant than in the case of non-irrigated crops, because irrigated crops show much less fluctuation in yield from year to year. In droughty years not only the individual plant number but also the size of the plants is smaller in non-irrigated, more widely spaced plant stands than in irrigated ones.

In rainy years, on the other hand, the individual plants may be better developed in non-irrigated stands, owing to the wider spacing, but even then the yield average per unit area will probably be lower.

Thus, my answer to the question is that the surplus yield obtained as a result of irrigation is due partly to the larger individual plant number, and partly to the higher yield per plant.

TÓTH, M.: In the case of intensive, high level farming in general, and of irrigation farming in particular, the average yield is decide mostly by the number of plants per unit area (productive surface). The increase in the number of plants is undoubtedly limited by certain factors (e.g. insolation conditions); biological research aimed at improving the yield-forming characteristics of the plant are therefore of great importance.

UJVÁROSI, M.: In irrigated crop production larger yields are equally due to the higher number of plants per unit area and the larger yield per plant. This feature is also specific to variety and has to be experimentally determined in each case separately.

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PÁL, GY.: **The optimum irrigation variety is not particular about the air content of the soil, it can fully utilize the amount of water and nutrient supplied and has not a long vegetation period. Do you not think that due to the appearance of pathogens and the danger of lodging involved with the increased stand density and plant height of irrigated winter wheats, the yield surplus it was hoped to attain by satisfying the water demands of the plants will be lost, and that at the same time the multiplication of aquatic weeds in wheat stands grown in a monoculture will be promoted?**

ALMÁSI, T.: The problem of intensive wheat irrigation affects a large area of the world. After twenty years of work in this field I feel that the length of the stalk depends at least as much on the nutrient management of the producing farm as on the efforts of the breeder. Optimum stand density and plant height (controlled by human intervention) may also ensure resistence to certain pathogens. For environmental protection and economic reasons, too, systematic prevention should be preferred to expensive chemical control. In farms which apply intensive irrigation the cheapest way of preventing overgrowth by weeds is to develop an optimum or nearly optimum plant stand.

The advantages of growing wheat in a monoculture have not yet been convincingly demonstrated. I do not think that winter wheat — a crop which — efficiently utilizes winter precipitation — would be the most suitable for intensive irrigation.

ÁCS, A.: Such a danger certainly exists! Determining and applying the proper rate of irrigation requires great professional skill. Water and nutrient should be supplied in quantities which will not cause lodging in wheat due to too strong a vegetative character. This is especially so before flowering, otherwise catastrophic yield losses will occur. This point must not be considered to be of general validity either. There are differences between the wheat varieties in their reaction to the same amount of water. Strong-strawed, wheat varieties with high standability, particularly those with high resistance to diseases, can tolerate more water than sensitive varieties. Things must always be considered in relation to all the factors.

As to wheat grown after wheat: wheat cannot be grown in a monoculture without a yield reduction; it can be sown in the same place in two successive years at the most.

BALLA, L.: If the variety grown is not suitable for irrigation the appearance of pathogens, due to the increased stand density and plant height, combined with lodging may result in the loss of the expected yield surplus. Hence, for the purpose of irrigation farming special varieties which respond to and pay back the investment must be bred.

The appearance of the weeds characteristic of wet or damp areas is a real danger. Nevertheless, provided the crops are not in a monoculture, this danger can be lessened. In addition, irrigation farming must be associated with a general improvement in soil cultivation and with increased agrotechnical discipline. In this case the danger of weeds can be eliminated.

BUDAVÁRI, K.: For the time being winter wheat is the only crop in Hungary which should only be irrigated occasionally, to replace any lack of natural precipitation. Thus, in years when there is abundant rainfall in the first half of the hydrological year (from 1st October to 31st March) irrigation should not be applied to winter wheat. In this way, even in those years when the crop is irrigated the extent of infection by pathogens will not be greater, and lodging will not be more serious than in rainy years. These problems should, of cource, be overcome by appropriate measures (by growing suitable varieties, carrying out plant protection, etc.) rather than by eliminating irrigation.

FRENYÓ, V.: Every new method of production creates new conditions for pathogens and weeds. It can thus be taken as certain that the irrigation of winter wheat will also raise a series of plant pathological problems. However, the consequences can hardly be judged in advance from the point of view of plant physiology. It is likely that the irrigated wheat stand will be more susceptible to lodging, for example, but a theoretical consideration of either lodging or any other undesirable consequence is bound to be rather dubious. A reliable answer to the question can only be expected from practice.

FÜRI, J.: In the case of irrigation farming I consider it absolutely necessary to grow short-strawed wheat varieties which do not lodge and consequently will not be overgrown by weeds or present a favourable site for pathogens. If the wrong variety is chosen not only the yield surplus attained by irrigation, but even more than that may be lost, as happened last year.

GYENGE, J.: In spite of the fact that I have spent more than two decades in an arid region I am more and more convinced that with a higher standard of soil cultivation, nutrient supply and plant protection the irrigation of winter wheat is definitely harmful, uneconomic and increases the already extremely high production costs. The cost per q of yield rises and the yield increase is not in proportion either with the increase in cost or with the profit, not to mention the fact that the large amount of precipitation usual in spring may cause a disaster, since winter wheat is one of the most sensitive crops to over-irrigation. The danger is further increased by the operation of centrifugal fertilizer distributors, which are tending to become a definitely harmful implement in Hungarian agriculture. Lodging beginning in strips and later becoming general in ceral fields adds to the problems involved with irrigation.

If other agrotechnical factors, local knowledge, etc. are made proper use of at the correct time, winter wheat makes good use of the precipitation falling during the growth season, as proved by the cereal yields in the country in recent years (Tables 1, 2 and 3).

Table 1

Amount of precipitation in the growth season, wheat yield average, and amount of water used to produce 1 q grain yield in the "Petőfi" Co-operative Farm, Nagyrábé

Year	Precipitation in the growth season, mm	Wheat yield average, q/ha	Water required for 1 q grain yield, mm
1970	728.1	11.82	62
1971	465.2	17.40	27
1972	350.2	23.30	15
1973	430.8	37.80	11
1974	474.1	31.89	15
1975	596.4	37.57	16
1976	324.6	40.14	8
1977	664.7	50.62	13
1978	558.7	46.08	12

Table 2

Amount of precipitation in the growth season, wheat yield average, and amount of water used for the production of 1 q grain yield in the "Vörös Csillag" Co-operative Farm, Füzesgyarmat

Year	Precipitation in in the season, mm	Wheat yield average, q/ha	Water required for 1 q grain yield, mm
1951	427	17.7	24.12
1952	405	11.6	34.91
1953	858	16.3	52.64
1954	518	8.7	59.54
1955	585	18.1	32.32
1956	637	12.5	50.96
1957	628	15.6	40.26
1958	467	12.7	36.77
1959	473	23.5	20.13
1960	435	23.1	18.83
1961	493	23.8	20.71
1962	360	21.3	16.90
1963	548	22.4	24.46
1964	455	22.8	19.96
1965	732	28.1	26.05
1966	599	24.1	24.85
1967	591	27.7	21.34
1968	493	28.6	17.24
1969	665	35.9	18.52
1970	692	15.8	43.80
1971	471	35.9	13.12
1972	322	34.0	9.47
1973	393	40.1	9.80
1974	523	34.7	15.07
1975	584	37.7	15.49
1976	380	49.2	7.72
1977	588	45.3	12.98
1978	540	51.4	10.05

In wheat the emphasis should be laid on the application of other agrotechnical methods, and irrigation should be omitted.

HARMATI, I.: In winter wheat irrigation certainly increases the stand density and plant height, promotes the appearance and multiplication of pathogens, and as a result of all this, the danger of lodging becomes greater. Irrigation may thus reduce rather than increase the yield, and may even cause a deterioration in quality. Special care must therefore be taken when growing wheat under irrigated conditions. Less firm-strawed wheat varieties showing susceptibility to diseases and intensive tillering should be irrigated

Table 3

Amounts of water used for the production of 1 q yield in different wheat

Year		Bezos-taya	Kavkaz	Avrora	Mv-1	Libellula	Sava	Jubi-leinaya 50
1975	Average yield, q/ha	28.3	31.7	27.7	23.7	37.4		
	Precipitation, mm	584	584	584	584	584		
	Water required for 1 q yield, mm	20.64	18.42	21.08	24.64	15.61		
1976	Average yield, q/ha	42.1	39.5	51.9	51.1	49.4	54.7	56.9
	Precipitation, mm	380	380	380	380	380	380	380
	Water required for 1 q yield, mm	9.03	9.62	7.32	7.44	7.69	6.95	6.68
1977	Average yield, q/ha		31		41	47.3	47.6	39.9
	Precipitation, mm		588		588	588	588	588
	Water required for 1 q yield, mm		18.97		14.34	12.43	12.35	12.0
1978	Average yield, q/ha				47.1	50.8	55.9	46.9
	Precipitation, mm				540	540	540	540
	Water required for 1 q yield, mm				11.46	10.63	9.66	11.51

only in the case of serious water deficiency, and even then with not more than 40—50 mm of water at a time. Wheat grown under irrigated conditions must not be sown with a germ number higher than 4.0 million/ha, and since the effect of nitrogen is increased by irrigation the rate of nitrogen fertilization should be slightly reduced. When growing wheat after wheat, irrigation in the second, and particularly in the third year is only advisable in the case of severe drought, because of the increased danger of root diseases spreading in the crop.

Irrigation of the recently introduced, firm-strawed, high yielding wheat varieties involves less danger and results in larger surplus yields. When wheat is grown for not more than two years on the same site and is provided with adequate weed control and irrigation, it will not be overgrown by aquatic weeds.

HORVÁTH, I.: The statement made in the first sentence, that the ideal irrigation variety should not have a long vegetation period, is disputable, as there is generally a positive correlation between the length of the vegetation period and the yield.

The problems formulated in the second half of the question are not related with the properties specified in the first sentence. They are not theoretical problems but can be settled in concrete experiments. It should also be noted here that stand density, plant height, the appearance of pathogens, the danger of lodging, and interactions between these factors are considerably influenced by the properties of the variety. The same applies to a possible overgrowth by "aquatic" weeds parallel to irrigation. ("Uliginal" would be a better term for these plants than "aquatic".)

KISS, A. S.: If irrigation is carried out property, using the optimum amount of water, there will be no increase in the damage caused by pathogens and lodging. In irrigated winter wheat the number of infections with Cercosporella, Septoria, leaf and stem rust and Fusarium did not increase, the plants did not lodge, and infection by powdery mildew decreased in the dry years of 1972/73 and 1973/74, while in 1974/75 (wet year) lodging and increased infections occurred. This can be explained by the fact that a higher rate of irrigation or a larger amount of precipitation do not make the microclimate as favourable for microorganisms as a wet year does. The improved nutrient supply ensured by the irrigation gives some protection from the so-called weakness parasites. Unless there is constant over-irrigation the excessive growth of aquatic weeds need not be feared either.

varieties grown in the "Vörös Csillag" Co-operative Farm, Füzesgyarmat

Mv-4	Mv-5	Zlatna-Dolina	Mura	Parti-zanka	N Ranna 1	N Ranna 2	Kom-polti 1	GK-3	GKF-2	GK-IK 2
49	49									
588	588									
12.0	12.0									
54.3	42.2	51.4	57	54.1	55.7	54.4	42.3	36	44.4	43.9
540	540	540	540	540	540	540	540	540	540	540
9.94	12.80	10.51	9.47	9.98	9.69	9.93	12.77	15.0	12.16	12.30

KOVÁCS, G.: As a consequence of irrigation in wheat various pathogens appear, and lodging results in the loss of the surplus yield. Although irrigation is an agrotechnical factor, it substantially modifies the joint effect of the ecological factors. This calls attention to the importance of breeding wheat varieties for resistance to lodging as well as to powdery mildew, Fusarium and other pathogens appearing in irrigated wheat stands. Further, the new variety should have strong stalks and high producticity. In the case of wheat there need be no fear of a possible overgrowth by aquatic weeds. For the past three decades since irrigation farming was introduced in Hungary, it is mainly Echinochloa sp. that have spread and are now found in Hungarian wheat fields. However, the rapid development of wheat exercises a shading effect on Setaria italica a weed which germinates and grows rather late, so the spreading of this species is unlikely to cause substantial damage to the wheat stands.

LELLEY, J.: At present there are hardly any winter wheats which have been bred specifically for irrigation farming. Among the spring wheats produced by Borlaug only a few approach the irrigation ideotype. Nevertheless, such varieties will not be long in appearing. If breeders succeed in combining the most favourable length and strength of straw with pathological resistance and the most economical coefficient of assimilation in the same variety, then this wheat will give a considerably larger yield under irrigated conditions than the varieties grown without irrigation. The task is not simple, however.

As far as the milling and baking qualities are concerned, the prospects are less promising. It will probably take a long time to achieve a resounding success in this field.

Weed control is certainly not an insoluble problem, but unfortunately we are still very far from a wheat monoculture in the true sense of the word. It is surprising that this important question is not studied anywhere with the thoroughness it deserves. Yet the time will come when growing wheat in a monoculture over large areas would be highly desirable.

LŐRINCZ, J.: Wheat should not be grown in a monoculture under either irrigated or dry conditions, much less so than maize. The yields of strong-strawed varieties resistant to pathogens could be increased by irrigation provided the method and quality of irrigation did not cause lodging.

MIHÁLYFALVY, I.: The breeding of winter wheat for disease resistance and short straw has become necessary with the wide introduction of irrigation in this crop. The increased air humidity caused by irrigation is highly favourable for the spread of various plant diseases (e.g. powdery mildew). Considering that wheat does not demand water supplements every year, there need be no fear of wheat being overgrown by aquatic weeds even when it is grown in a monoculture. It would be wise to concentrate on the special chemical weed control of irrigated crops.

NÉMETH, S.: It would be worth further listing the basic criteria of the "ideal irrigation variety". For my part, I think excellent stalk strength, resistance or tolerance to bacteria, fungi and insect pests, etc. are definitely worth mentioning.

The irrigation of winter wheat often leads to contradictory results. If an "ideal irrigation variety" were available and the "ideal irrigation variety" were available and the "ideal water supply" could always be ensured, the irrigation of winter wheat would be highly economical. Unfortunately, the stalks of the wheat varieties commercially grown in Hungary is not sufficiently strong; with an expected yield of 60—80 q/ha they often lodge as a consequence of June rainfalls. Since a lodged grain crop is exposed to damage by various pathogens, both the quality and yield are considerably reduced, often to below the yield level of non-irrigated winter wheat.

According to a national survey the large-scale irrigation of winter wheat has resulted in a yield of 75 q/ha. (The yield of non-irrigated wheat is 40.6 q/ha.) In good irrigation farms the irrigation of winter wheat has led to a 10.2 q/ha (36%) increase in yield average (non-irrigated wheat yielded 44.8 q/ha.) According to our experimental data the irrigation of winter wheat is not always successful because of the factors outlined above. In 1977, for example, irrigated winter wheat varieties yielded 8—10 q/ha less than non-irrigated varieties!

It should be added that on areas equipped for irrigation winter wheat is only grown in a monoculture to a very limited extent.

PÁSZTOR, K.: The question deals with theoretical problems which do not occur in practice. With an ideal water supply, under optimum conditions, the problems mentioned do not exist.

PLETSER, J.: Even a plant variety which is indifferent to the air content of the soil and is ideally suited for irrigation will give a larger yield when the soil is not saturated to full water capacity, since the role of soil biology cannot be neglected. Although nutrients thus exhausted can be replaced by the application of fertilizers, the latter, combined with the superfluous irrigation water, will increase the production costs. Excessive irrigation may cause a great deal of damage by decreasing the soil temperature, creating favourable conditions for infection by fungi and by resulting in the lodging of cereals; in general, it may be more harmful than a drought. Thus, plant varieties ideal for irrigation may be sensitive to the air content of the soil, as this is also required from many other points of view.

POSGAY, E.: Plant varieties ideal for irrigation, in other words, varieties suitable for intensive cultivation, must possess the characteristics required by intensive production conditions. The "ideal" water demand is that which, when fulfilled, ensures optimum (quantitative and qualitative) results. This goes for wheat as well. Irrigation is not aimed at turning wheat into an "aquatic plant". Farms do not introduce irrigation exclusively for wheat. Wheat is usually only irrigated if it is sown on an irrigation area for the purposes of crop rotation. Here there can be no question of a monoculture, but it is advisable to plant firm-strawed, disease resistant, short-stalked intensive varieties.

POZSÁR, B.: Over an average of many years the total amount of autumn—winter—spring precipitation has been sufficient for semidwarf cereals to produce large average yields. Irrigation is not advantageous in wheat production because of its damaging effect on the soil structure. By comparison the increased phytopathological and harvesting losses cause considerably less damage. In my opinion damage due to the uneven distribution of precipitation could be lessened by applying mulch at the stages of milky and full ripening.

SZABÓ, L. GY.: In my opinion, winter wheat only gives a positive reaction to irrigation in well-cultivated soil. Irrigation may be particularly successful in the case of fodder wheat, but wheat will never really be included in the group of crops which need regular irrigation.

SZALÓKI, S.: The demand for soil ventilation is primarily a specific character, though the character of the variety cannot be neglected either. In my opinion, the latter is mostly connected with resistance to root diseases.

In the case of alfalfa I found that when the ground-water level was raised until it was close to the soil surface, roots which had become immersed in water were destroyed within a few days, while those in the upper ventilated soil layers, and even the shoots, developed various vascular diseases, which presumably caused the death of the plants.

Plants less susceptible to these diseases, on the other hand, survived and were regenerated even if very few roots were left. Moreover, some plants developed new roots from the lower nodes of the shoots to replace the roots which had been destroyed.

I do not agree that a short vegetation period is always a requirement for irrigation. A short vegetation period in addition to high productivity is, naturally, an advantage in a variety. But, in general, the length of the vegetation period as a varietal feature is in positive correlation with productivity and dynamic water demand.

Farms usually grow varieties with both short and longer vegetation periods (e.g. for maize). It is obvious that varieties with shorter vegetation periods, which require less water should be grown on the non-irrigated areas, and those with longer vegetation periods on the orrigated areas.

In many years of experiments on maize, varieties with long vegetation periods (MvSC 580, SzSC 648) gave much higher yield averages and a more intensive response to irrigation, and not only their growth but often their biological development too was more rapid than that of earlier varieties (e.g. SzSC 363). In treatments well supplied with water the plants often flowered earlier and the ears ripenend more quickly.

It is true, on the other hand, that if irrigation is applied late, in the last third or quarter of the growth season, it will usually prolong the vegetation period of maize.

As to the actual question anxiety is justified in the case of cereals.

For the time being no variety is available for which irrigation and an abundant nutrient supply would be free of risk, since both these factors greatly increase the danger of lodging. And lodging, especially when it occurs early, may jeopardize the yield.

Cereals do not have a high demand for water. If 300 mm water is available to the plants in April, May and June, high yields can be obtained. In practice this means that for cereals grown in a monoculture without second crops, if the soil cultivation is carried out properly, serious water deficiencies seldom occur even on non-irrigated areas.

Hence, it is only practicable to grow these plant species on irrigated areas as often as is absolutely necessary for crop rotation and for the undisturbed execution of melioration work and manuring. Growing cereals in a monoculture on irrigable areas is, in my opinion, pointless.

UJVÁROSI, M.: It is a well-known fact that in the case of winter wheat an excessive nutrient supply and too large a number of plants per unit area result in increased stand density and a consequent multiplication of pathogens, lodging and an ultimate reduction of yield. Irrigation, when it is routinely applied, may result in similar phenomena. In my opinion the optimum water requirement should be determined experimentally, in the same way as the plant number, rate of fertilization, etc. are, and then the danger will not exist. Alternatively, the yield loss can be prevented by plant protection operations modified according to need.

If supplementary irrigation only is applied there need be no feat of overgrowth by aquatic weeds, since this method of irrigation can at the most result in the multiplication of mesophilous weed species, which are regularly controlled anyway. Under these circumstances the life conditions of aquatic weeds are not available.

VARGA, M.: The fear that the yield surplus obtained with an optimum water supply will be lost in wheat monocultures because of the lodging and the appearance of pathogens involved with the increased stand density and plant height, and due to the promotion of the overgrowth of water-requiring weeds is only justified when irrigation is applied without other complementary agrotechnical procedures. If, however, the various interrelated and complementary methods available to agriculture form an integral part of the irrigation system used in wheat production, the above dangers can be avoided. There are numerous possibilities of diverting the danger, and the progress of biology promises still wider possibilities for the near future.

a) The increased plant height and the danger of lodging which it involves no longer represents a serious problem. To prevent lodging in cereals, apart from producing and using varieties with high standability, growth retardants which check the elongation of the stalk, particularly CCC, are widely applied all over the world. In Hungary, "Regulator-60", which was specially produced for this purpose, is widely used. According to the literature (WEAVER ibid.), in all the wheat varieties so far included in CCC treatments the three lower internodes have shown the greatest and the two upper ones the least shortening. This phenomenon is very important in relation to the effect of nitrogen fertilization on wheat. Under irrigated conditions a high rate of fertilization in wheat is increasingly necessary to obtain large yields and good quality. The increasing amounts of nitrogen result, however, in the elongation of all the internodes in general, and of the lower ones in particular, which can be counterbalanced by CCC treatment.

According to results obtained abroad the CCC treatment may increase the volume of yield in some varieties by 30% or more compared to the yields of untreated, lodged wheat stands; this can be attributed to the elimination of lodging, because if lodging does not occur in the untreated wheat stand, the yield-increasing effect of CCC is usually only 5%, which is due to the higher degree of tillering and the resulting larger number of ears per plant and sometimes of grains per ear as well. When using CCC against lodging the compound has shown the greatest effect on most soil types when applied in combination with nitrogen fertilization, and the growth inhibition caused by the retardant has been found to be more noticeable under moist soil conditions than when the water supply is limited.

It should be noted that in many experiments ethrel has also proved suitable for preventing lodging in wheat and other cereals; it is more efficient than CCC in increasing the number of tillers.

b) Owing to the increased density and higher humidity, the microclimate of irrigated plant stands is favourable for the appearance and spreading of pathogens. However, possibilities of avoiding this danger already exist, and the new methods are expected to be even more efficient.

Breeding irrigation wheat for resistance to pathogens will certainly become more and more important in the future, since the genetic resources in this respect are far from being fully exploited. Yet, since maximum results with respect to all factors cannot be attained simultaneously in the course of breeding, concessions are usually made on resistance to diseases and pests, because modern chemical plant protection offers excellent supplementary solutions (Láng, ibid.). In irrigated wheat growing the chemical control of pathogens should obviously play a more important role.

A further successful method of reducing the possibility of diseases and infection by pathogens may be the growth stimulation of wheat at an early stage of development (in order to cause a time-shift) and the acceleration of the life processes with a view to shortening the vegetation period. The life cycles of Hungary's major crops, including the wheat varieties grown with irrigation, can be shortened by breeding; and in present agricultural practice it is already possible to influence the development processes of plants with growth substances — naturally within the limits of the genetic and environmental conditions. Both trends belong to the inner reserves of biology.

c) I think irrigation changes not so much the quantity as the quality — the composition — of the weeds in wheat stands. Weed species with higher water requirements will probably gain ground. With complex weed control, i.e. through prevention and the combined application of agrotechnical and chemical weed killing methods, and with appropriate crop rotation, the spreading of weeds can be checked even under irrigated conditions. Herbicides and herbicide combinations suitable for use in chemical weed control are already available, and further rapid progress can be expected, as there are ample reserves in this field too.

The problems raised in the question can only be solved with the co-operation of experts from various branches of agriculture and biology in the fields of basic research, applied research and development. If the anxieties formulated in the question are to be allayed by exploiting the possibilities, better co-ordination between crop farmers, plant physiologists, geneticists, biochemists and plant protection experts is definitely needed, together with the complex application of scientific results.

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CHRONICA

SITUATION OF AGRICULTURE IN THE MEZŐFÖLD REGION IN THE SPRING OF 1945

1. The Mezőföld as a regional unit, and its general characteristics

The Mezőföld is a geologically and geographically well definable regional unit of Transdanubia, the western part of Hungary. It is bordered in the north-east and north by a sunken hill ridge at Érd, the valley and the upper reaches of the Benta, a stream flowing into the Danube, and the valley of the Sajgó stream; in the north-west by the edge of the Vértes and Bakony hills, as far as Fűzfő bay, which forms the north-western corner of Lake Balaton; in the west by the shore of Lake Balaton between Balatonfűzfő and Siófok; in the south by the tectonic erosion valley of the Sió Canal as far as Simontornya, and from then on by the terrace field stretching to Dunaszentgyörgy; and finally in the east, by the steep bench forming the western bank of the Danube (Ádám *et al.* 1959). The regional unit measures 124 km in a north-south and 70 km in an east-west direction; excluding the Velence hills, which form an island in the region, the Mezőföld has an area of 4500 km^2. The regional unit has an average altitude of 120—180 m above sea level, and consists of plains and sloping hills; its Pannonian layers are thickly covered by loess (to a depth of 50 m at Paks, for example). The regional unit is divided largely from north-north-west to south-south-east by the Gaja and Sárvíz valley into a smaller western and a larger eastern part. The valley, about 70 km long, is characterized by vast meadows and peat fields (Anonymous 1961).

In 1945, as an administrative district the Mezőföld belonged mostly to Fejér County and to a smaller extent to the counties of Veszprém and Tolna, unlike the present situation, which has been in effect since 1950, whereby the Mezőföld belongs almost fully to Fejér County, except for the south-eastern corner which comes under the administration of Tolna County.

In 1944—45 the regional unit was almost exclusively agricultural in character, with the large estate system even more dominant than on the national average; fifty per cent of the cultivable land was owned by 374 families.[1] Industry was only to be found at Székesfehérvár, the geographical, historical and administrative centre of the regional unit; in other places, such as Enying, Perkáta, Szolgaegyháza, Dunaföldvár, Simontornya, etc., only minor industrial plants related to agriculture (mills, distilleries, tanneries) were in operation.

2. The Mezőföld in World War II (3rd December 1944—22nd March 1945)

On 3rd December 1944, during the second phase of the Budapest offensive, the 20th, 21st and 31st rifle-corps of the 4th army of guards of the Soviet 3rd Ukrainian Front, launching an attack from the Mohács bridge-head, reached the southern border of the Mezőföld,

[1] Fejér megyei Levéltár (FmL), Alispáni iratok; Fejér vármegye alispánjának jelentése 1945. évről (Fejér County Archives, Sub-prefectorial documents; report by the sub-prefect of Fejér County on the year 1945).


CZECHOSLOVAKIA
SOVIET UNION
ROMANIA
YUGOSLAVIA
AUSTRIA
MEZŐFÖLD
BUDAPEST
GYŐR-SOPRON
KOMÁROM
NÓGRÁD
PEST
HEVES
BORSOD-ABAÚJ
ZEMPLÉN
SZABOLCS-SZATMÁR
HAJDU BIHAR
SZOLNOK
BÉKÉS
CSONGRÁD
BÁCS-KISKUN
FEJÉR
VESZPRÉM
VAS
ZALA
SOMOGY
TOLNA
BARANYA
Duna
Tisza
Dráva
Balaton
SOPRON
GYŐR
KOMÁROM
TATA
ESZTERGOM
TATABÁNYA
SZENTENDRE
VÁC
SALGÓTARJÁN
BALASSAGYARMAT
MISKOLC
SÁTORALJAÚJHELY
SÁROSPATAK
KAZINCBARCIKA
ÓZD
EGER
GYÖNGYÖS
HATVAN
GÖDÖLLŐ
JÁSZBERÉNY
LENINVÁROS
MEZŐKÖVESD
KISVÁRDA
NYÍREGYHÁZA
MÁTÉSZALKA
NYÍRBÁTOR
HAJDUNÁNÁS
HAJDÚBÖSZÖRMÉNY
DEBRECEN
HAJDÚSZOBOSZLÓ
KARCAG
KISÚJSZÁLLÁS
SZOLNOK
TÖRÖKSZENTMIKLÓS
TÚRKEVE
MEZŐTÚR
CEGLÉD
NAGYKŐRÖS
KECSKEMÉT
SZÁZHALOMBATTA
SZÉKESFEHÉRVÁR
VÁRPALOTA
VESZPRÉM
AJKA
PÁPA
OROSZLÁNY
BALATONFÜRED
TAPOLCA
KESZTHELY
SIÓFOK
DUNAÚJVÁROS
KALOCSA
KISKŐRÖS
KISKUNFÉLEGYHÁZA
KISKUNHALAS
CSONGRÁD
SZENTES
SZARVAS
BÉKÉS
BÉKÉSCSABA
GYULA
OROSHÁZA
HÓDMEZŐVÁSÁRHELY
SZEGED
MAKÓ
BAJA
SZEKSZÁRD
DOMBÓVÁR
KAPOSVÁR
KOMLÓ
PÉCS
MOHÁCS
SZIGETVÁR
NAGYATÁD
NAGYKANIZSA
ZALAEGERSZEG
SZOMBATHELY
KŐSZEG
SÁRVÁR
KAPUVÁR
CSORNA
MOSON MAGYARÓVÁR


TATABÁNYA
BUDAPEST
Csákvár
Tabajd
Vértesacsa
Vál
Gyúró
Tordas
SZÁZHALOMBATTA
Zámoly
Vereb
Kajász
Martonvásár
Lovasberény
Pázmánd
Baracska
Pátka
Meleghegy
Ráckeresztúr
Sárkeresztes
Nadap
Velence
Moha
Sukaró
Kápolnásnyék
Pákozd
Velencefürdő
Velencei-tó
Gárdony
Agárd
Besnyő
Dinnyés
Beloiannisz
SZÉKESFEHÉRVÁR
Pusztaszabolcs
Sárkeszi
Sárszentmihály
Börgönd
Zichyújfalu
Iváncsa
Nádasladány
Úrhida
Szabadbattyán
Seregélyes
Adony
Jenő
Belsőbáránd
VESZPRÉM
Kőzethegy
228
Tác
GORSIUM
Szabadegyháza
Küngös
Füle
Polgárdi
Felsőszentiván
Csajág
Csősz
Aba
Sárosd
Perkáta
Rácalmás
Hangos-domb
Balatonfőkajár
Soponya
Sárkeresztúr
Hantos
186
Lepsény
Tarnóca
Mezőszentgyörgy
Nagylók
DUNAÚJVÁROS
Kisláng
Káloz
Sárszentágota
Nagyvenyim
Balatonbozsok
Felsőbörzsök
F E J É R
Enying
Mátyásdomb
Mezőfalva
Kislók
SIÓFOK
Nagyhörcsök-puszta
Sárbogárd
Kisapostag
Kabókapuszta
Nagykarácsony
Baracs
Balatonszabadi
Dég
Sárvíz
Pusztaszentmihályfa
Lajoskomárom
Pusztaegres
Középbogárd
Örspuszta
Rétszilas
Előszállás
Mezőkomárom
Mezőszilas
Alap
Dunaföldvár
Sáregres
Alsószentiván
Igar
Cece
Simontornya
Bölcske
Vajta
Németkér
Gyapa
Madocsa
Bikács
Akalacspuszta
Dunakömlőd
Györköny
Paks
Nagydorog
103
Pusztahencse
Csámpa
Dunaszentgyörgy
KALOCSA
Sárvíz
Duna
Tolna
DOMBOVÁR

between Siófok, Simontornya and Dunaföldvár, where the defence line, code-named "Jenő", of the German and Hungarian troops belonging to the "Fretter-Pico" operational group was situated. After several days of fighting the Soviet troops broke through the defence lines, and the troops of the German 57th armoured corps and the 72nd infantry corps retreated to defensive positions forming the left wing of the "Margit" position between Balatonakarattya, Csaját, Füle, Polgárdi, Tác, Fövénypuszta, Külső- and Belsőbáránd-puszta, Dinnyés, Kápolnásnyék, Baracska, Martonvásár and Érd. This vast system of defence, consisting of three protective zones with an average breadth of 30 km, which divided the Mezőföld into two, roughly in an east-west direction, was the first of four extensive defence systems protecting the south-eastern reaches of the German Empire. This defence system changed the Mezőföld into a large arena in the battle for Western Hungary and for the south-eastern areas of the German Empire. The battles fought in the Mezőföld from 3rd December 1944 to 22nd March 1945 were unparallelled, both in their dimensions and the destruction they caused, in the history of warfare in Hungary.

The catastrophic destruction of agriculture in the Mezőföld began at the time of the Soviet attack and the German-Hungarian retreat between 3rd and 19th December 1944. The retiring German-Hungarian troops evacuated the villages and estates wherever possible. However, because of the rapid retreat this could not always be accomplished. For example, the evacuation of the large stocks of feed, grain and animals in the Előszállás estate of the Cistercian Abbey at Zirc was prevented due to the determined action of the estate manager. The central buildings and manors of the estate were requisitioned according to the laws of war, put under military command and guarded by the Soviet army supply corps. In spite of the fact that the stocks stored on the estates were used to cover the needs of the fighting troops and field-hospitals, the estates were not devastated, which was of great importance for the new economic life which began after the fighting ended in April 1945 (Farkas 1970b).

The villages and farms situated in the zone forming the "Margit" position were in the most serious position, partly because a considerable proportion of the fields were laid waste by the engineering corps in building the defences. For example, an 80 km entrenchment and an anti-tank trap 500 m long, 5 m wide and 3 m deep were dug on the outskirts of the village of Aba, a 20 km long entrenchment in the neighbourhood of Seregélyes and a 21 km entrenchment and a 4500 m long anti-tank ditch in the fields of the village of Velence (Virág 1947). At the same time, extremely heavy fighting developed along the "Margit" position as early as 6th December 1944. Balatonfőkajár became the scene of particularly bitter engagements when it was penetrated by the rifle-corps of the Soviet 20th guards, against which a series of counter-attacks were launched by the troops of the German 1st armoured division. The village was almost completely devastated: of the 452 dwelling-houses 185 were totally ruined, while 162 suffered 75% and 105 30% damage; 181 civilians died and 43 were wounded; 98% of the livestock perished and nearly all the farm implements were destroyed with the houses. ". . . on the basis of the above", wrote the village notary on 4th May 1945, "the general state of the village is almost hopeless. Even strangers say that there is hardly any other village that has suffered so much as Balatonfőkajár."[2]

On the morning of 20th December 1944 the Soviet 46th army and the 4th army of guards concentrated in the central area of the Mezőföld began to break through the "Margit" position. While the 46th army mounted an offensive between the Danube and Lake Velence and enclosed Budapest from the west, the 4th army of guards advanced between Lake Velence and Lake Balaton towards the city of Komárom to form the outer circle in the encirclement

[2] Veszprém megyei Levéltár (VmL); Enyingi járás iratai; Balatonfőkajár jegyzőjének jelentése az enyingi járásnak [Veszprém County Archives, documents of the Enying district; report by the village notary of Balatonfőkajár to the district administration of Enying (3) 4th May 1945].

of Budapest. By 25th December even the northern part of the Mezőföld had been left by the assaulting troops. Only the western border of the region along a line from Bodajk, Sárkeresztes, Moha, Csór, Ősi, Berhida and Csajág to Balatonakarattya, was the scene of desperate fighting. The populations of villages in this zone were evacuated by both the Soviet and the German military authorities. The villagers were made homeless for months on end and almost everything they possessed, houses, livestock and farm implements, was destroyed, while the land was laid waste by trenches, defence works and tank tracks. The village hardest hit by the fighting was Sárkeresztes, which was captured and recaptured 16 times, and consequently only five of its 245 dwelling-houses remained fit to live in. In the neighbourhood of the village there were three lines of trenches with a total length of 15 km, and when the fighting ended 140 bunkers, 280 gun-emplacements and 600 shell-holes were waiting to be filled up. The villages of Moha, Ősi and Balatonfőkajár were in a similar state. The destruction was further increased by the counter-attacks code-named "Konrad-II" and "Konrad-III" which were started on 7th and 18th January 1945 by the 1st cavalry corps of the German operational group "Balck" between Sőréd and Sárkeresztes in the main direction of Zámoly, and by the 4th SS armoured corps between Csór and Balatonakarattya in the main direction of Martonvásár—Budapest. In the course of the two German counter-attacks first the north-western, then the entire southern, south-eastern, eastern and north-eastern area of the Mezőföld became the scene of a battle even more devastating than the fighting in December 1944. In the "Konrad-III" offensive the German 3rd armoured corps reached the Danube between Dunaföldvár and Iváncsa. The severe German counter-attack and the heavy fighting in the two-pronged Soviet counter-offensive, which was begun on 27th January 1945 from the southwestern area of Budapest and the Dunaföldvár district, resulted in the further destruction of villages and agriculture. It was during this period that the villages in the Adony district suffered the most serious damage and losses. At Dunapentele, for example, where the German armoured corps were the first to reach the Danube, 293 (32.5%) of the dwelling-houses were damaged and 95% of the draught and farm animals perished. Severe losses befell the village of Ercsi: 29.4% of the dwelling-houses (350 in number) were damaged and 80% of the livestock perished. At Adony only 49, a mere 6%, of the dwelling-houses were demolished, but 83% of the livestock was destroyed. Further villages which suffered heavy losses in the region were Pusztaszabolcs (180 dwelling-houses and 75% of the livestock), Rácalmás (103 dwelling-houses and 60% of the livestock), Iváncsa (102 dwelling-houses and 75% of the livestock) and Ráckeresztúr (95 dwelling-houses and 70% of the livestock). There were 60—75% losses in livestock in the other villages of the district too. The battles in January and February 1945 caused serious damage in many villages of the Sárbogárd district as well. At Hercegfalva (Mezőfalva) 29.3% of the dwelling-houses (300 in number) and 80% of the livestock were destroyed. At Szolgaegyháza, while only 15 dwelling-houses were ruined, 90% of the livestock perished, and the retreating German troops set the distillery and glycerine factory on fire on 2nd February. (The western part of the district was devastated by the March fighting.) In the Székesfehérvár district Kápolnásnyék was the hardest hit during the January fighting: 44 dwelling-houses were demolished, 379 were damaged and the Müller mill was burned down, and in nearby Pettend-puszta all the buildings on the Luczenbacher and Mecsér estates were reduced to ruins.[3]

By 10th February 1945 the retreating troops of the German 4th SS armoured corps and the 3rd armoured corps took up a firm defensive position on the eastern side of the Mór—Székesfehérvár road, on the north-eastern and eastern edges of Székesfehérvár, and along a line stretching from Dinnyés, Börgönd, Belső- and Külsőbáránd-puszta, Fövény-puszta, Tác, Polgárdi, Mezőszentgyörgy and Lepsény to Balatonaliga. By 13th February both the retreat-

[3] FmL. Fejér vármegye és Székesfehérvár város szociális felügyelőjének iratai, 186/1946. (Fejér County Archives. Documents of the social inspector of Fejér County and the city of Székesfehérvár, 186/1946.)

ing German troops and the attacking forces of the 26th Soviet army had taken up a defensive position along this line, and between 10th February and 5th March it was again the defensive zone of the "Margit" position, as in the fighting in December 1944, that became the field of battle. Opposite the "Margit" position the 30th, 135th and 104th rifle-corps of the 26th Soviet army also built a defence system 25—30 km in breadth, consisting of three defensive zones. The first position of the main defensive zone, constructed opposite to the German lines, consisted of two or occasionally three interconnected trenches, at a depth of 1.5—2 km. The second position, also at a depth of 1.5—2 km, consisting of two interconnected trenches, was situated at a distance of 2.5 km from the edge of the main defensive zone. The second defensive zone ran from Kisvelence through Tükrös-puszta, Seregélyes, Sárkeresztúr, Kishörcsök-puszta, Dég and Lajoskomárom to Mezőkomárom, and from there along the southern bank of the Sió to Siófok. The second defensive zone consisted of only two trenches, with ditches connecting them, and the settlements within the zone were prepared for an all-round defence. The third army defensive zone was set up at a depth of 3—4 km between Kisvelence, Tükrös-puszta, Pusztaszabolcs, Perkáta, Hercegfalva and Dunapentele. The Soviet rifle and engineering corps moved an enormous amount of earth; in the district of Seregélyes, for example, they dug out a 20 km long entrenchment, and in the fields around Sárosd trenches with a total length of 15 km, 120 artillery posts and 900 other heavy armament emplacements were constructed. Vast minefields were established between the two opposing armies. In front of the main defensive zone of the 26th Soviet army, 730 anti-tank and anti-personnel mines were laid, with even more in the most likely directions for tank attacks: 2700 anti-tank and 2500 anti-personnel mines. As a consequence, 4600 ha of arable land in the fields around the village of Seregélyes, for example, and 9 ha of forest around Zámoly were mined. In spite of continual mine clearance, the outskirts of 32 villages (a total area of 12,660 ha) in Fejér County were still recorded as dangerous in 1946 (VIRÁG 1947).

On 22nd February 1945 the Royal Hungarian Ministry of the Interior gave orders for an evacuation: villages at a distance of up to 5 km from the front fell within zone "A", from which area all the civilians were evacuated, if necessary, by force. This was also the fate of the population of Mezőszentgyörgy, where the following report was made by the village notary on 1st May 1945: ". . . The village of Mezőszentgyörgy was the scene of warfare from 6th December 1944 to 19th January 1945. Fifty per cent of the dwelling-houses were damaged and became unfit to live in. Forty per cent of the animals (horses, cattle, poultry) perished. From 19th January to 22nd March 1945 the village was under German occupation, and after its evacuation by military forces the still existing animals, produce, furniture and other movable property were destroyed or carried away, so that only the ruins and the bare walls remained."[4]

The Soviet "Balaton defence manœuvre", started on 13th February 1945, was interrupted on the morning of 6th March 1945 by an offensive on the part of the German 6th SS armoured corps (code-name: "Spring Awakening"). The main force of the offensive against the defence lines of the 26th Soviet army developed in the Mezőföld, between Dinnyés, Tác and Balatonvilágos. For the fourth time in four months the Mezőföld again became a vast battlefield. The German offensive lasted ten days; during this time the German 3rd armoured corps and 2nd SS armoured corps broke through the first defensive zone of the Soviet troops, and advanced to a line stretching from Velence, Tükrös-puszta, Zichyújfalu, Sárosd, Henrik-major, Sárkeresztúr, Nagyhörcsök, Hatvanpuszta, Sáregres, Simontornya and the Sió Canal to Siófok. Along this line the German offensive was halted and suffered a defeat. In spite of serious losses on both sides the Soviet supreme command launched the Vienna offensive on

[4] VmL. Enyingi járás iratai. Mezőszentgyörgy község elöljáróságának jelentése az enyingi járáshoz, 1/1945. május 1. [Veszprém County Archives. Documents of the Enying district. Report by the parish council of Mezőszentgyörgy to the district council of Enying (1/1st May 1945).]

16th March 1945, the decision for which had been made on 17th February. The main attack, started by the Soviet 9th army of guards and then by the tanks of the 6th army of guards, developed in the northern part of the Mezőföld, centred on the district of Zámoly. During the fighting against the dogged resistance of the German 4th SS armoured corps some villages in the Gaja valley were brought to the verge of total destruction. Of the 298 dwelling-houses in Fehérvárcsurgó, which was at the centre of the break-through, 208 were burned down; the village was a sea of flames, which destroyed practically everything. This battle put the finishing touches to the ruination of the villages of Magyaralmás, Sárkeresztes and Moha (see below).

After the main attack, on 20th March, the 27th and 26th Soviet armies, which were concentrated in the south-eastern area of the Mezőföld along the Budapest—Simontornya railway line, launched an offensive; then three corps of the 26th Soviet army began to attack from the direction of the Sió Canal. The Soviet infantry and armoured troops, which attacked with gigantic forces, had left the Mezőföld in a westerly direction between Várpalota, Berhida and Balatonfüred by 22nd March.

The desperate fighting during the German offensive in March and the subsequent Soviet counter-offensive completed the destruction of the villages in the district of Székesfehérvár, and to some extent in those of Sárbogárd and Enying, but at the same time brought peace to the Mezőföld.

3. State of agriculture in the Mezőföld after the end of the war (March—May 1945)

After the departure of the retreating German and assaulting Soviet armies, practically the whole of the Mezőföld resembled a vast abandoned battle-field: "... In the devastated villages and farms, in fields criss-crossed with trenches, trampled down by tanks and strewn with mines, the farmers were unable to do anything in the first few weeks. Owing to the lack of seed, draught power and farm implements the spring work did not begin until April 1945", Dr. Ferenc Szirbik, sub-prefect of Fejér County wrote in his report. During the first weeks the population gradually returned to the ruined, burnt-out villages and farms, that were filled with wreckage, carcasses and dead soldiers. Although, the authorities filtered back, the offices did not begin to function until the middle of April; the head of the Fejér County administration issued the first circular on 14th April 1945. The first paragraph of the circular called for the provisions of the land reform No. 600/1945. M.E., issued by the Provisional National Government and already proclaimed in those parts of the country which had been liberated, to be implemented immediately. But first of all, measures indispensable for the maintenance of life had to be carried out. Corpses and carrion had to be buried and blocked roads cleared without delay. Animals, draught power, agricultural machines in working condition and fuel supplies had to be registered; land fit for use had to be surveyed to see how much of it had been planted in the previous autumn and how much left unsown. Seed stocks and requirements had to be estimated and agricultural work started at once with the draught power and seed available, in such a way that the tractors were used in that part of the fields marked out by the authorities.

The survey produced miserable results. After the fighting agricultural conditions in the villages of the Mezőföld were characterized by four factors: an average 50—70% reduction in the sowing area; most of the implements and vehicles in the devastated farms had been destroyed; 50—100% of the draught and farm animals had perished; there was not sufficient seed available.

The destruction of the sowing area, partly in building the fortifications before the fighting and partly during the fighting itself, caused the most serious problems almost everywhere. It took years of work before land which had been dug up to form trenches, and which was strewn with mines and covered by wreckage, was restored to a state suitable for cultivation. Of a total 258,859 ha of arable land in Fejér County, 104,597 ha was left uncultivated in the summer of 1945. Of this, 12,632 ha — belonging to 32 villages — was mined.

Székesfehérvár, the "City of Ordeals", the centre of the Mezőföld, was perhaps in the most serious situation. Of the 7867 ha of arable land in the city, 1810 ha was totally unusable because of the fortifications minefields and scattered war material and wreckage. By 1st December 1946 81,931 mines had been collected from the mined areas and rendered harmless; in the course of this work 58 soldiers and 52 civilians were killed. The removal of the mines rendered 1632 ha of land fit for use, but a further 170 ha of arable land remained dangerous minefields[5]

Among the villages in the Székesfehérvár district, Zámoly, a village situated at the centre of some of the heaviest fighting, was in a similarly miserable state. 120 km of entrenchment, 800 gun-emplacements and 2000 other firing positions, 400 burnt-out tanks, the wreckage of 20 crashed aeroplanes and 80 guns, and 8.5 ha of minefields rendered agricultural cultivation impossible on all but 860 of its 3450 ha in the spring of 1945. The situation was similar in the nearby village of Sárkeresztes, where, over an area of 2220 hectares, 15 km of trenches, 600 bomb-craters, 280 firing positions and 140 bunkers needed filling up, and the wreckage of 190 tanks and 80 other vehicles were scattered over the fields, most of which were still mined. Of the 3960 ha of arable land in Kápolnásnyék only 1470 ha could be cultivated because of 25 km of entrenchments, 500 firing pits, 500 artillery positions and 4500 m of anti-tank trenches, and because of the mines laid in the fields. In the neighbouring village of Velence, too, only 50% of a total arable area of 2750 ha was cultivable, owing to the 26 km of entrenchments dug in the fields, and the remains of 70 tanks and innumerable mines and shells scattered everywhere. Of the 6379 ha in Seregélyes, a village at the centre of the fighting, 4590 hectares spring of 1945 owing to the trenches (80 km in total length), anti-tank ditches (500 m long, 3 m deep and 5 m wide), artillery positions (300) and firing pits (5000). The situation was similar in other districts. In that part of the Vál district which formed part of the Mezőföld, the village of Vereb was in the most desperate state: on an area of 1610 ha 12 km of trenches and 5 km of anti-tank ditches had to be filled in by the farmers; there were about 1200 gun-emplacements and firing positions, and a total of 70 burned-out tanks and the wreckage of 35 guns were scattered over the fields. So the villagers were only able to cultivate 600 hectares in the spring of 1945. The conditions were just as bad at Pázmánd, the neighbouring village, where only 1124 hectares of the total 2518 ha area could be used for agricultural production in the spring of 1945. From the Sárbogárd district, one of the areas which suffered the greatest destruction, detailed data are only available for one village, Sárosd, where only 793 ha of the 4016 ha arable area could be cultivated in the spring of 1945 owing to a 15 km entrenchment, 900 firing positions and 120 artillery emplacements which had been dug in the fields, and because of the minefields. No detailed data are available on the villages in the Adony district; only the amount of land left uncultivated in the spring of 1945 is known: Adony, 1436 ha; Dunapentele, 1390 ha; Ercsi, 4367 ha; Iváncsa, 689 ha; Kisapostag, 660 ha; Perkáta, 788 ha Pusztaszabolcs, 690 ha; Rácalmás, 879 ha; Ráckeresztúr, 1436 ha.[6]

There are no data on the post-war conditions of villages in the Enying district, which then belonged to Veszprém County; the reports only showed the acreages of cultivated

[5] FmL. Polgármesteri iratok. Székesfehérvár thj. város polgármesterének jelentése az 1946. évről, 4., 17. (Fejér County. Mayor's documents. Report of the mayor of the municipal borough of Székesfehérvár on the year 1946, 4, 17.)

[6] FmL. Fejér vármegye és Székesfehérvár város szociális felügyelőjének iratai, 186/1946. (Fejér Country Archives. Documents of the social inspector of Fejér County and the city of Székesfehérvár, 186/1946.)

(autumn and spring sowing separately) and uncultivated land. Of a total of 4718 ha of arable land in the village of Enying autumn and spring cultivation was carried out on 3448 ha; 1264 ha could not be cultivated. At Mezőszentgyörgy autumn cereals were sown on 382 ha, spring cereals on 20 ha, and 1738 ha of the total arable area of 2115 ha was left uncultivated. Of the 2954 ha of arable land at Lepsény autumn sowing was carried out on 565 ha and spring sowing on only 39 ha, while 1742 ha of arable land remained uncultivated. At Lajoskomárom autumn cereals occupied 7105 ha and spring cereals 689 ha, while uncultivated land made up 2506 ha of the total 5106 ha of arable land. Of the 1880 ha of arable land at Csajág 1108 ha was cultivated (280 ha sown to autumn cereals, 115 ha to spring cereals, and 475 ha to row-crops) while 764 ha remained uncultivated. At Mezőszilas only 4022 ha of a total of 8240 ha arable land was cultivated in the spring of 1945: 2068 ha were sown with autumn cereals, 574 ha with spring cereals, and 1379 ha with row-crops. Of the 6000 ha of arable land at Dég only 2413 ha was cultivated: 1620 ha was sown with autumn cereals, 793 ha with spring cereals, while 4885 ha remained uncultivated. The amount of land cultivated and sown out of a total of 2384 ha of arable and at Balatonfőkajár was 1724 ha: 689 ha was sown to winter wheat and barley; in the spring 172 hectares were sown with spring barley, 40 ha with potatoes, 45.9 ha with sunflower, 344 ha with maize and 689 ha with fodder crops.[7]

Apart from the arable land serious losses were caused in the orchards and vineyards of the Mezőföld as well. At Magyaralmás 80% of the 51 ha of orchards was destroyed. At Zámoly about a thousand fruit-trees and a 17 ha vineyard, including 200 wine-cellars, were devastated (Virág 1947). In the Fejér County part of the Mezőföld 50% of the fruit-trees were destroyed during the fighting.[8]

The experimental rice farm established in 1943 by the side of the Sárvíz Canal was totally neglected during the fighting and became overgrown by grass. (Restoration was not begun until April 1946, Szirbik 1946.)

Another important cause of the reduction in the sowing area was the catastrophic destruction of the draught-animal stock (and with it the livestock). The reduction in the livestock began during the retreat and the evacuation of the population, and increased due to the requisitioning foreseen by the laws of war, and during the military operations. Losses of animal in Fejér County, the largest part of the Mezőföld, were very severe:[9]

	Cattle	Horses	Pigs	Sheep
1938	95,106	32,652	190,659	53,001
1945	16,863	9,938	25,542	852
Reduction	82,32%	70,37%	85,29%	97,47%

In the spring of 1945 there were only 3722 pairs of draught animals in the whole of Fejér County. Of these 501 were to be found in the Adony district, 1008 in the Sárbogárd district and 1251 in the Székesfehérvár district, which formed part of the Mezőföld.

[7] VmL. Enyingi járás iratai. Jelentések a nevezett körzetből. (Veszprém Country Archives. Documents of the Enying district. Reports from the district in question.)

[8] FmL. Alispáni iratok. Fejér vármegye alispánjának jelentése 1945. évről. (Fejér County Archives. Sub-prefect's documents. Report of the sub-prefect of Fejér County on the year 1945.)

[9] FmL. Alispáni iratok. Fejér vármegye alispánjának jelentése 1945. évről. (Fejér County Archives. Sub-prefect's documents. Report of the sub-prefect of Fejér County on the year 1945.)

As regards losses of animals, Székesfehérvár was again the worst hit:

	Cattle	Horses	Pigs	Sheep
1938	3.612	2.910	5.554	—
1945	313	253	613	—

There were serious losses of animals in the villages in the Székesfehérvár district as well:

		Cattle	Horses	Pigs	Sheep
Fehérvárcsurgó	1938	625	167	1072	—
	1945	105	5	63	—
Zámoly	1938	4000	220	6000	800
	1945	20	8	—	—
Sárkeresztes	1938	850	138	2005	—
	1945	36	1	20	—
Magyaralmás	1938	1300	300	1820	1050
	1945	35	3	—	—
Moha	1938	535	80	800	15
	1945	9	21	—	—
Kápolnásnyék	1938	1070	344	8116	—
	1945	2	23	16	—
Seregélyes	1938	2500	1210	12300	750
	1945	151	166	21	—
Velence	1938	894	520	2450	—
	1945	4	4	10	—

No data are known for other villages in the Székesfehérvár district. Data are only known for two villages belonging to the Mezőföld in the Vál district:

		Cattle	Horses	Pigs	Sheep
Vereb	1938	1600	350	6800	150
	1945	—	6	100	—
Pázmánd	1938	1060	502	1853	822
	1945	36	42	11	15

From the Sárbogárd district data are only available for the village of Sárosd (VIRÁG 1947):

	Cattle	Horses	Pigs	Sheep
1938	2430	681	7012	13,300
1945	201	97	465	444

The reduction in livestock in other villages in the district is only recorded as a percentage: 50% at Sárbogárd, 54% at Sárszentmiklós, 65% at Igar, 70% at Alap, 75% at Alsószentiván and Előszállás, 80% at Cece, Hercegfalva and Vajta, 85% at Nagylók, Sárosd and Sárszentágota, 90% at Sárkeresztúr and Szolgaegyháza, and 92% at Káloz. From the Adony district too, only percentage data are available on the reduction in the livestock: 60% at Rácalmás, 70% at Barcs, Perkáta and Ráckeresztúr, 75% at Iváncsa, Kispostag and Pusztaszabolcs, 80% at Ercsi, 83% at Adony, and 95% at Dunapentele.[10] The data from the Enying district are more favourable; in the reports the numerical data of draught and farm animals were separately listed:

Enying

	Draught animals	
	horses	oxen
1938	978	229
1945	152	52

	Farm animals					
	cows	bulls	sows	boars	ewes	rams
1938	510	26	1400	20	180	10
1945	108	1	56	1	54	—

Lespény

	Draught animals	
	horses	oxen
1943/44	332	89
1945	81	54

	Farm animals					
	cows	bulls	sows	boars	ewes	rams
1943/44	544	72	1428	107	490	29
1945	122	40	72	6	3	1

[10] FmL. Fejér vármegye és Székesfehérvár város szociális felügyelőjének iratai, 186/1946. (Fejér County Archives. Documents of the social inspector of Fejér County and the city of Székesfehérvár, 186/1946.)

Lajoskomárom

	Draught animals		
	horses	oxen	buffaloes
1943/44	800	20	6
1945	120	40	4

	Farm animals			
	cows	bulls	sows	boars
1943/44	720	22	400	25
1945	240	4	180	5

Mezőszilas

	Draught animals		
	horses	oxen	buffaloes
1943/44	430	520	12
1945	300	200	4

	Farm animals					
	cows	bulls	sows	boars	ewes	rams
1943/44	800	25	1000	40	300	50
1945	300	4	250	20	20	6

Balatonszabadi

	Draught animals		
	horses	oxen	buffaloes
1943/44	123	237	8
1945	43	129	4

The great losses in draught animals caused difficulties not only in the agricultural work on peasant farms and large estates but also in marketing. On 16th May 1945 the available stock of cart-horses was estimated. It was found that in the Enying district, where there had been 71 cart-horses in the summer of 1944, only 18 cart-horses were left at Siófok.

Apart from in the private peasant farms, it was in the dairy farms, some managed by large estates and some by private enterprises, which produced milk for public supply, that the destruction of livestock was particularly disastrous. Of the nine dairy farms operating in the Enying district in the summer of 1944 only those at Balatonszabadi, Enying and Siómaros were still functioning, with reduced stocks, in 1945 (Balatonszabadi: 116 cows in 1944, 70 in 1945; Enying: 202 cows in 1944, 52 in 1945; Siómaros: 100 cows in 1944, 40 in 1945). The other six dairy farms at Balatonfőkajár (52 cows), Dég (325 cows), Lajoskomárom (180 cows), Lepsény (179 cows), Mezőkomárom (70 cows) and Mezőszilas (180 cows) were completely destroyed in the course of the fighting.

The sub-prefecture of Fejér County had applied to the Ministry of Agriculture for a 10 million pengő loan as part of the 60 million pengős required for the reconstruction of agriculture in the county, but this was not to be spent on purchasing animals, so the only solution was to put in a claim, as other counties did, for some of the cattle given to Budapest by the Red Army, as these were intended for the reconstruction of agriculture and for increasing the livestock, not for the public food supply of the capital. When the cattle were distributed 35% of the animals were given to Fejér County, which was in the worst situation of all the counties in Hungary. However, only two-thirds of the animals could be used. The remaining third was not even distributed: in consequence of the hardships they went through while being driven over great distances, and of an epidemic of foot-and-mouth disease, the animals perished in large numbers. The remaining animals were distributed on 21st August 1945; the farmers paid for the cattle in food, which was delivered in several instalments from 1st November 1945 to 31st August 1946.

The spreading of epizootics was a concomitant of the war conditions. Some diseases, e.g. strangles and breeding paralysis, appeared in 1946 after a latent period in 1945. Strangles appeared in the villages of Kőszárhegy, Szabadbattyán, Alap and Pusztaegres. Breeding paralysis, a disease native in the eastern countries, only appeared at Sőréd and Sárkeresztes. Scab occurred in 85 of the 100 villages in Fejér County (in 1731 yards), though in the Enying district it was only found at Mezőkomárom in May 1945. Swine-fever only reached epidemic proportions at Sárbogárd and in the Enying district (Szirbik 1946).

In the interests of organized animal husbandry, the sub-prefecture of Fejér County issued a decree No. 311/1945 on 1st June 1945 ordering that the male animals in private possession should be registered and used jointly for breeding. This was necessitated by the fact that, of the breeding animals owned by the Livestock Breeding Foundation and kept on the Székesfehérvár city farm, 24 breeder bulls and 18 boars were lost in the course of the military operations.[11] Only 18 breeder bulls and 5 boars survived the war, which was not enough to supply the whole county. Therefore, soon after the fighting ended, the Fejér County Livestock Breeding Foundation purchased 56 breeder bulls with the support of the Ministry of Agriculture and used them for the purposes of public breeding, together with the 16 breeder bulls and 19 boars found in the district of Enying. Considering the importance of horse breeding, 17 state-owned stallions were used for public breeding in Fejér County (4 at Dunapentele, 1 at Felsőtöbörzsök, 4 at Székesfehérvár, 6 at Bernátkút), as were the stallions, some Nonius and some English half-bred, in private possession: 1 at Sárosd, 6 at Sárbogárd, 1 at Sárszentmiklós, and 1 each in the villages of Igar, Tác, Szolgaegyháza, Polgárdi, Alap and Sárkeresztúr (Szirbik 1946).

Due to this organized activity, the growth of the livestock by 31st December 1945 was considerable:[12]

District	Horses	Oxen	Bulls	Cows	Calves	Pigs
Adony	3143	84	44	2730	387	6321
Sárbogárd	2905	609	103	6527	693	11,342
Székesfehérvár	3057	1411	86	3524	545	6462

[11] FmL. Polgármesteri iratok. Székesfehérvár thj. város polgármesterének jelentése 1946. évre, 4., 45. sz. táblázat. (Fejér County Archives. Report by the sub-prefect of the borough of Székesfehérvár on the year 1946. 4, Table No. 45.)

[12] FmL. Alispáni iratok. Fejér vármegye alispánjának jelentése 1945. évről. 5. (Fejér County Archives. Report by the sub-prefect of Fejér County on the year 1945, 5.)

However, it was not until 1953 that the livestock in Fejér County reached 95% of the pre-war (1935) level, and this fell to 92% by 1968 (ANONYMOUS 1970).

Besides destroying the livestock, the military actions decimated the stock of farm implements (vehicles, tractors, etc.) belonging to farmers in the Mezőföld. Large numbers of carts, the most important means of transport for passengers and goods in village circles, were destroyed. The number of carts available in 1938 and 1945 is given below for a few villages:

	1938	1945
Kápolnásnyék	229	28
Sárosd	540	60
Seregélyes	820	125
Pázmánd	434	5
Zámoly	450	—
Sárkeresztes	220	6
Fehérvárcsurgó	338	44

With respect to tractors and agricultural machinery, the situation in the spring of 1945 in the Fejér County districts of the Mezőföld was as follows:

District	Tractors	Threshers	Harvesters
Székesfehérvár	53	43	7
Sárbogárd	59	45	15
Adony	27	48	8

In the Enying district only 5 out of 15 tractors were left at Mezőszilas, 8 at Lajoskomárom and only 1 out of 8 in Lepsény; at Mezőszentgyörgy 3 of the 8 tractors were fit for use, while at Enying 6 of the original 12 were left — but there was no fuel anywhere.[13]

On 21st April 1945 the sub-prefecture of Fejér County reported to the Ministry of Food that, owing to a serious deficiency in draught power, 172,600 ha in the county had still not been ploughed. Since there were 300 tractors in working condition in the county, but no fuel, an immediate allocation of 210,000 kg diesel oil, 60,000 kg petrol, 30,000 kg paraffin and 300,000 kg lubricating oil was applied for, so that at least the maize could be sown by the beginning of June. The allocation was granted on 25th May, and in addition to the above, the villages in the Enying district were also able to take delivery of 14,990 kg diesel oil and 20,280 kg paraffin from the Nitrogen Works at Pét by 30th May.[14]

[13] VmL. Enyingi járás iratai. A Veszprém vármegyei főispán 18/1945. sz. rendeletére az enyingi járáshoz beérkezett községi jelentések 1945 májusából. (Veszprém County Archives. Documents of the Enying district. Village reports from May 1945 to the Enying district by order No. 18/1945 of the prefect of Veszprém County.)

[14] VmL. Enyingi járás iratai. Enyingi járás főjegyzőjének körlevele, 145/1945. május 26., valamint: FmL. Fejér vármegye alispáni iratai, 39/1945. április 21. sz. irat. (Veszprém County Archives. Documents of the Enying district. Circular of the recorder of Enying district, 145/26th May 1946; Fejér County Archives. Sub-prefect's documents from Fejér County, 39/21st April 1945.)

In spite of the serious deficiencies in draught-power and fuel, agricultural work started up everywhere at the beginning of May 1945. Yet, many villages in the region could have said what the notary of Tác wrote in his report: "... The village presents a most distressing picture. All the dwelling-houses have been damaged, most of them are completely ruined. The village has been ransacked. There is no livestock, and no grain, except just enough to supply the population until the new crop is harvested. There is no feed for the animals and no seed for spring sowing. There are no draught animals, or at most only one or two wretched horses and a few pairs of oxen ..." According to official data, the women and children from Magyaralmás carried the seed to their fields from the neighbouring counties on their backs, and for lack of draught animals dragged the ploughs and harrows themselves. In other places the soil was cultivated using requisitioned draught power; those in possession of draught animals were obliged to work for others on two days of the week in exchange for manual labour or other compensation.[15]

Owing to the catastrophic state of the public food supply throughout the country a survey of the seed and livestock on the abandoned estates was ordered on 5th May 1945; then on 7th May 1945 the Ministry of Food issued decree No. 10.030/1945 forbidding the slaughtering of cattle, buffaloes and sheep for the purpose of either private or public consumption. Decree No. 1180/1945. M.E., issued by the Provisional National Government on 21st May, ordered the organized production of sunflower seed with a view to making up for the serious deficiencies of fat in the country. Farmers with 3 to 6 ha of land were obliged to sow sunflower on 5%, and those with farms of over 6 ha on 10% of the land. Due to the delay in issuing the decree, the lack of draught power, and the mines which were a constant danger in the fields, it took some time for the order to be carried out. The reports all quote the same reasons: "... I report", wrote the village notary at Enying in his report, "that 4.5 ha of sunflower has been sown at Enying and 11.5 ha at Balatonbozsok. The farm committees of both villages have reported that there is not a single farmer in the villages who has failed to plant the required amount of sunflower without sufficient reason, because when the population returned to their homes after the fighting had ceased, they found the houses sacked, they had no draught power, and even if this was later available, they did not dare to go into the fields because of the danger of mines, and finally the sowing time was over."[16]

The spring work was also hindered by the fact that the 10 million pengő loan applied for at the Ministry of Agriculture by the sub-prefecture of Fejér County in order to give assistance to the farmers in ploughing and sowing, arrived late and could no longer be used for that purpose.

In spite of the great difficulties, the farmers of the Mezőföld began the spring farmwork. "... Spring sowing is in process", reported the notary of Mezőszentgyörgy on 1st May 1945, "but due to lack of fuel for the tractors, and because of the presence of minefields and unexploded munition, the work is going very slowly". As regards the spring work actually performed, data are only available for the Enying district; in the documents from the districts in Fejér County the autumn and spring work is recorded together in a single column dealing with the cultivated land. Work proceeded slowly in the Enying district too: at Balatonfőkajár (2350 ha) 172 ha were sown to spring barley, 40 ha to potatoes, 51 ha to sunflower and 375 ha to maize by 9th May 1945; at Dég (7430 ha) 2410 ha were sown with spring cereals by 10th

[15] VmL. Enyingi járás iratai. Csajág község körjegyzőjének jelentése az enyingi járásnak, 1/1945. május 1. (Veszprém County Archives. Documents of the Enying district. Report by the district notary of the village of Csajág to the district administration of Enying, 1/1st May 1945.)

[16] VmL. Enyingi járás iratai. Enying község jegyzőjének jelentése az enyingi járásnak, ad. 138/1945. július 14. (Veszprém County Archives. Documents of the Enying district. Report by the village notary of Enying to the district administration, 138/14th July 1945.)

May; at Mezőszilas (8239 ha) 574 ha were sown to spring cereals and 1379 ha to row-crops by 7th May; at Csajág (1880 ha) 115 ha were sown with spring cereals and 475 ha with row-crops by 5th May (the figures in brackets indicate the total arable area).[17]

Parallel with the spring operations, the harvesting of the maize from the previous year, which was still standing, was also started. By 9th June 1500 q had been harvested in the Adony district, 8000 q in the Sárbogárd district and 850 q in the Székesfehérvár district. As was only to be expected, mines exploded in several places; in the neighbourhood of the village of Sárosd, for example 4 people died and 14 were injured.[18]

In order to improve the public food supply the condition and capacity of the mills was surveyed in the middle of May. In the Enying district 9 flour-mills were in working condition, but only the one at Lajoskomárom had any stock (3500 kg wheat), while the Mezőkomárom mill was working for the Soviet army.

If agriculture was to be put back on its feet the seriously damaged road network definitely needed reconstructing. In the course of the fighting, damaged tanks being towed to the repair service depots practically ploughed up the municipal and village roads in many places. Due to the shortage of materials, however, the reconstruction of the roads was still a problem waiting to be solved in 1946. Road and railway bridges which had been blown up not only hindered communications but also produced other serious problems, not least the danger of flooding. The lifting of the Zichy Bridge at Adony and the remains of the bridge at Szürkevár was begun immediately after the fighting had stopped and was completed by the beginning of 1946, as was the lifting and reconstruction of the passenger bridge over Dinnyés station, the wooden bridges at Tác, Nagyhörcsök, Hatvan and Fáncs, the MÁV (Hungarian State Railways) bridge at Rétszilas, and the reinforced concrete bridges at Kishörcsök, Cece, Vajta and Szabadbattyán. At the same time, war damage to the Nádor canal-system, which conducts masses of water from the Bakony and Vértes hills to the Danube, represented a serious problem. The fact that 107 km (52%) of the 208 km long embankment of the Nádor Canal had been destroyed by trenches, gun-emplacements and bunkers raised the possibility of flooding. The greatest danger of flooding was represented by four extensive bursts at Sárszentmihály (Nádor Corner), Sárkeresztúr (Dinnyés Canal), Sárszentágota (Lóki Canal) and Sárbogárd (Tinódi Canal), the repair of which was of vital importance (Szirbik 1946).

4. The Mezőföld and the 1945 land reform

In the Mezőföld, like everywhere else in the country, a decisive change was brought about in the agriculture by decree No. 600/1945. M.E., issued by the Provisional Government of Hungary on 15th March 1945, ordering the abolishment of the large estate system and the allocation of the land to those who cultivated it. Owing to the protraction of the military operations in the Mezőföld, the National Committees of Fejér and Veszprém Counties gave priority to the distribution of land and, on 11th April 1945, ordered the immediate organization of land-distributing and land-claiming committees under the guidance of the County Councils for the Redistribution of Landed Property. The land-claiming committees were formed in most villages on 20—25th April; by the end of the month they had achieved considerable results. (The distribution of land was still not fully completed, however, even by the end of 1945.)

[17] VmL. Enyingi járás iratai. Az említett községek jegyzőinek jelentése az enyingi járásnak (Veszprém County Archives. Reports by the notaries of the villages in question to the district administration of Enying).

[18] FmL. Alispáni iratok. Fejér vármegye alispánjának jelentése a vármegye főispánjának, 794/1945. június 9. (Fejér County Archives. Sub-prefect's documents. Report by the subprefect of Fejér County to the prefect of the county, 794/9th June 1945.)

In consequence of the land reform, those parts of the Mezőföld which belonged to Fejér and Veszprém Counties changed over from the large estate system to the small-holding system.

Within a 30 km radius of Budapest (in the Mezőföld this concerned the villages of Baracska, Kajászó, Kápolnásnyék, Ercsi, Martonvásár, Pázmánd and Vereb) landed properties larger than 27 ha, and outside this area those over 54 ha, were expropriated and placed in a pool of land to be distributed. In the months preceding the land reform, based on data available for 1st April 1945, there were 13,734 landed properties 3—14 ha in size in Fejér County, which covered the major part of the Mezőföld. The number of estates covering 54 to 540 ha was 413, with a total area of 78,818 ha. There were 94 estates of between 540 and 1650 ha and above, with a total are of 96,115 ha. There were secular landed properties covering over 1724 ha at Aba (1762 ha), Adony (2819 ha), Ercsi (3367 ha), Lovasberény (3051 ha), Perkáta (2420 ha), Pusztaszabolcs (2205 ha), Sárosd (1859 ha) and Zámoly (1804 ha). The largest landed property was owned by the Cistercian Abbey of Zirc: 7425 ha at Előszállás and 7071 ha at Hercegfalva. At Sárszentágota the Hungarian Catholic Religious Foundation had a large estate of 2879 ha. Landed properties of over 540 ha were entirely expropriated. Some land was given back to the churches, e.g. 13 ha at Előszállás and 288 ha at Hercegfalva were returned to the Abbey of Zirc (Farkas 1970a).

The distribution of land was completed most rapidly, by the end of April, in areas where the fighting in the villages had already ceased in December 1944. Thus, in Ercsi some 6000 ha of land, including the 3000 ha Wimpfen estate, was distributed among 897 claimants by the end of April. By 30th April all the available and at Perkáta, primarily the 2200 ha Imre Hunyadi estate, had also been distributed among 464 claimants, but 7500 ha, planned for distribution to a further 152 claimants, had to be taken from the lands of nearby estates (Farkas 1970a). On 27th April the first land was distributed to the agricultural workers of Székesfehérvár as well; first the 800 ha of land at Bárándpuszta and Sashalompuszta, then, on 2nd May, fields along the road to Tác, the Futás fields and land at Felsőtelek were distributed. A total of 2300 ha was distributed among the landless people of the city; of this 1200 ha was the property of the city, while the rest was requisitioned from private persons.[19]

In some villages, e.g. Dunapentele, the seat of the district with the highest concentration of land, the distribution of land was protracted; in spite of repeated warnings by the County Council for Land Re-distribution it was only completed on 15th November 1945, with 950 ha distributed among 314 families (Salamon 1970).

In Fejér County, which covered the largest part of the Mezőföld, 58% of the farm population, a total of 28,742 persons, were affected by the land reform; 7205 of them had been farm servants, 10,083 agricultural labourers and 6428 small-holders. After the land reform the number of small-holdings measuring 3—13 ha rose from 13,734 before 1st April 1945 to 31,022.[20]

In April and May 1945 the epoch-making effects of the land reform were still only partly felt; moreover, the unclarified property rights resulting from the rapid execution of the land reform represented an inhibiting factor in getting agricultural work off the ground.

In his report for the year 1945, Ferenc Szirbik, sub-prefect of Fejér County, formulated the essence of the land reform in the following way: "... It is, however, quite certain, that these figures (here the sub-prefect is refering to the data of the land reform — Author's note)

[19] FmL. Polgármesteri iratok. Székesfehérvár thj. város polgármesterének jelentése 1946. évről (Fejér County Archives. Mayor's documents. Report of the mayor of the borough of Székesfehérvár for the year 1946).

[20] FmL. Alispáni iratok. Fejér vármegye alispánjának jelentése 1945. évről. 15. (Fejér County Archives. Report of the sub-prefect of Fejér County for the year 1945, 15.)

indicate the laying down of the foundations for a new conquest of Hungary in the as yet unpopulated lands of a county of large estates, and that this will prove an unshakeable foundation for the construction, strengthening and permanence of democratic Hungary!"

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AS I SEE IT . . .

THE FUTURE OF WHEAT GROWING IN HUNGARY

In Hungary, as in other countries of the temperate zone, wheat is of decisive importance among the cultivated plants, and is the crop grown on the largest area on the Earth. Since the development of the plough and the beginning of crop production it has occupied a special place in human nutrition. The beginning of wheat growing in the Carpathian basin dates

from prehistoric times, and its importance and role in the life of the people living here have grown ever since.

After several centuries of stagnation, the technology of wheat growing began to develop in the last century with the adoption of the crop rotation system, the wider treatment and application of manure, the introduction of ploughs, discs, harrows, etc., not to mention the advantages of mechanical sowing which gradually replaced hand sowing. The results of breeding, which was based in Hungary on the ancient local wheat varieties and started in the second half of the last century, also contributed to the development. Then the national yield level attained in this way by the turn of the century hardly rose again during the subsequent decades: the 11.8 q/ha yield average achieved in 1900—1909 only increased to 13.7 q/ha by 1931—1938.

The stagnation of wheat growing in that period can be attributed fundamentally to economic reasons. Hungary was then an important wheat exporter, so the prices were determined by the level of the international market, and the large amounts of wheat produced at a low prime cost by countries which had almost unrestricted amounts of newly cultivated, naturally fertile soils kept the prices low. In addition, wheat could be transported to the western countries by the much cheaper waterways, while the marketing of Hungarian wheat still had to rely on expensive road transportation. In these decades a difference in production intensity began to show between the exporters and importers of wheat, with the consequence that while the yield average stagnated in the exporting countries, the importing countries ensured higher marketing prices for the producers through protective tariffs, so that there was a rapid return for the money spent on yield-increasing investments.

During and after World War II the demand for wheat increased. After the reconstruction of wartime damage production began to take its normal course and a new phase of wheat growing set in. The national economy of Hungary, including agriculture, underwent a substantial structural adjustment, and the more favourable ratio between the price and production cost of wheat provided good conditions for an intensive system of wheat growing. Among other things, the ratio of wheat production to fertilizer consumption improved, the economic efficiency of fertilizer utilization increased, and the more favourable nutrient supply made it possible for the production potential of the wheat varieties grown to be fully exploited.

Farms with the most fertile soils in the country very soon found that the old steppe types of wheats were unable to give favourable responses to any further increase in the nutrient supply, so they considered a continuous change of variety to be necessary, as has been reported in detail by Lelley (Acta Agron. Hung., **28**, 423—430).

Simultaneously with this, mechanization also developed at a fast rate, thus raising the level of soil cultivation, making it possible to determine the optimum or nearly optimum sowing date and reducing harvesting losses, at the same time lowering the labour requirement for wheat growing.

The general introduction of chemical weed control, and in some cases the chemical control of diseases, also contributed to an increase in yield avarages.

Although all these factors increased the production costs to a considerable extent, the much larger yields obtained as a result of the new technology were nevertheless able to compensate for them. The national wheat yield average rose from 13.7 q/ha in 1931—1940 to 42.8 q/ha by 1978. This result approaches that of the Western European countries which were able to start on the road to intensive development much earlier due to protective customs duties. At the same time, it demolished the generally accepted belief that the semicontinental climate of Hungary, with its lower amount of precipitation, which is also unfavourably distributed, makes it impossible to obtain such large yields as those produced in the maritime countries, where the supply and utilization of precipitation is more favourable and, as a result, the efficiency of fertilization is better.

As another characteristic of the change taking place in Hungarian wheat production, the sowing area of wheat has been reduced. While between 1931 and 1940 wheat was grown in Hungary on 1606 thousand ha, in 1978 its sowing area was only 1324 thousand ha. This reduction is partly due to a similar rate of decrease in the total arable area of the country, and partly to the fact that in a number of farms wheat has been replaced by maize, a crop with higher productivity.

An increase in the yield average was able to compensate to a great extent for the area reduction, so the actual yield produced has been doubled compared to the thirties. Considering the fact that as living standards rise the consumption of cereals decreases, the wheat flour requirement of the country can be fully covered from a smaller area, and even the export of considerable volumes has recently become possible again.

This favourable picture of the development of wheat growing in Hungary is somewhat overshadowed by the unfavourable change that has taken place in the quality of the wheat crops. When examining the quality of wheats, the purpose for which they have been produced must always be kept in mind. Wheat flours from which bread suited to the Hungarian taste is to be made must have properties different from those required for the griddle-cakes (chapattis) consumed as everyday bread in many Asian countries, and different qualities again are expected from flours used for the production of pastas (macaroni, spaghetti, etc.) or confectionery products. And if the nutritional value of the foods prepared from wheat flour is regarded as the basis for classification the quality requirements to be met by the wheat will be different again.

Although the environment (soil and weather) influences not only the quantity of the wheat crop but also its quality, the most important qualitative features are genetically determined. The old Hungarian steppe-type wheats — Bánkúti 1201 in particular — excelled in baking quality, and were therefore sought after on the Western European markets to improve the quality of other wheats. They were even competitive with the hard wheats of Canada and the United States, which were also excellent.

The new highly productive varieties which are replacing the old wheats are mostly of medium quality and are thus satisfactory even by themselves; tasteful, attractive bread can be made from them. There are some, however, which do not fulfil the criteria for bread flour and must therefore either be mixed with quality improving flours so as to become suitable for bread-making, or be used for feeding purposes.

On the international markets it is primarily the good quality wheats which are in demand and which bring satisfactory prices. The conflict in Hungarian wheat production arises from the fact that while the level of production has been raised high enough to make a considerable volume of exports possible, the quality of the crop is not good enough to attain favourable export prices.

In evaluating the present situation of wheat growing in Hungary one must not forget that the 40 q national yield average hides considerable differences in yield. There are farms where the yield average is well above 50 q/ha, but those producing 30—35 q/ha of wheat are not few in number either. This wide range of yield averages is due to natural and technological reasons. In spite of the fact that the area of Hungary is not large, there are great differences in the quality and fertility of the soil, which may be lessened but not totally eliminated.

The easiest thing to do is to equalize the nutrient-supplying capacity of the soils, which has been done since the introduction of intensive fertilization. Since more phosphorus and potassium have been supplied to the field crops than is extracted with the yield the soils have become richer in nutrients, and even those which are naturally poor have been raised — faster or slower depending on the positive value of the nutrient balance — to at least a medium level of nutrient capacity. By means of nitrogen fertilization, differences in humus content between the soils can be lessened, even if they cannot be removed.

However, high nutrient capacity is only one of the criteria of soil fertility. The structure and water regime of the soil, properties which enable the roots to grow rapidly and vigorously, etc. are factors that can be influenced only at extremely high costs if at all, so yield differences due to soil fertility must be expected in the future as well. And even the climate is not uniformly favourable for wheat growing in all parts of the country. Variety and technology must therefore be adapted to the climate.

Besides the natural conditions, differences in the agrotechnical level have also contributed to the trend of wheat production in the individual farms.

After this brief survey of the present conditions of wheat growing in Hungary the future prospects can be outlined as follows.

The future of wheat growing in Hungary is fundamentally determined by the economic background, particularly by the level of prices attained on the export market and by the trend of production costs.

With the increase in the world population the demand for food is expected to continue to grow. Those countries which, owing to their high population density and low economic level, are unable to produce their own food requirements are relatively distant from Hungary geographically, so wheat exports to these countries would involve high transport costs even in the case of a solvent demand. This is the main reason why it is economically more advantageous to export wheat to Europe and to the Asian countries of the Near-East. The capacity of these markets is considerable compared to the volume of Hungarian wheat production, so there is a good chance of finding a foreign market for the surplus in the future as well. Thus, a lack of marketing possibilities is hardly likely to restrict the development of wheat growing in Hungary. The only question is: what price level can be attained on the international market?

This is closely related with the trend in production costs. Until recently the increase in production costs was caused mainly by an increase in investments (more fertilizer, more mechanical work, etc.). In recent years, however, a considerable increase in the price of the materials and assets utilized has been added to this, and as energy becomes more expensive this process will continue. Thus, investment costs must be expected to increase even at the present intensity of wheat growing, and the economic efficiency of production can only be maintained if the market price of wheat also rises. Although the world trend is in this direction, competition must be expected, just as it was in the thirties, from countries which, due to their more favourable natural conditions, will be able to produce wheat at a lower cost for some time to come.

Nevertheless, even under the present economic conditions there are possibilities for improving wheat production. However, this requires the elaboration of technologies much more differentiated than the present ones and better adapted to the natural conditions. Without aiming to give an exhaustive list, I should like to make this clear with a few examples.

The largest wheat yields are obtained on the excellent meadow soils of the Tisza region and of Baranya, Tolna and Fejér counties. On large-scale farms an average yield level of as much as 60 q/ha occurs in many cases, which means that it is the productivity of the available varieties that limits production development. In these soils the quality of the forecrop is less important, soil cultivation and seed-bed preparation are cheap and they can be carried out efficiently, so high quality sowing will ensure the quick and even emergence of the plants and the stand thus produced will give an optimum yield. As a result of the favourable soil conditions the fluctuation in yield caused by the weather is moderate, so consistently good crops can be expected from year to year. Naturally, in these regions even varieties which are most resistant to lodging and give a positive yield response to intensive conditions may be subject to damage caused by lodging under certain weather conditions. With a view to the development of wheat growing wheat varieties with higher production potential than the current ones are needed in these regions; in addition, the general application of stalk-shortening and straw-strengthening chemicals may help in increasing yield averages and yield consistency.

There is a considerable area on which water-logging or the inability of precipitation to infiltrate into the soil occasionally causes great damage to wheat stands. In dry years satisfactory yields can be obtained from these areas, but under extreme weather conditions — like those in 1979 — the damage may affect tens of thousands of hectares. Such areas are found not only in the lowlying parts of the Great Plain, in the neighbourhood of the best meadow soils, but also in Western Transdanubia. Under such conditions the development of wheat growing depends fundamentally on amelioration and water management. Owing to the high energy, and often high financial requirements of this very expensive soil-improving procedure, it can only be carried out gradually and can only make its effect felt in the trend of the national wheat yield average if it is carried out regularly and continuously. There are no quick returns on the investment either; this procedure will increase the costs of wheat growing even if — as is usual all over the world — a large part of the expense is met by the state.

Another long-term problem which has caused considerable difficulty in wheat growing, again in the Tisza region, is that of how to utilize the alkali soils which are scattered over the region; in favourable crop years they produce a satisfactory yield level, but in other years the quantity of yield does not even cover the expenses. These soils can only be ameliorated to a certain extent, so instead of amelioration it is better to speak of improvement. Since Sámuel Tessedik's initiative some 200 years ago a great bulk of scientific results and practical experience has accumulated, which still helps in improving the fertility of these soils on larger or smaller areas from year to year even today. Nevertheless, it is impossible to ignore the fact that the fertility of these soils will never reach the level of those which are naturally fertile.

However, wheat is one of the crops which can be most reliably and successfully grown on these soils, so the yield level of these areas will continue to exercise an unfavourable effect on the national yield average. At the same time, the unit production cost will also be higher than average, which must be taken into consideration when influencing the economic background. It is an advantage, on the other hand, that in the case of favourable weather conditions the crop quality is above average.

A considerable amount of Hungary's arable land is found in hilly regions. A large proportion of these areas are eroded soils deprived of the upper humous layer, though even the original "A" horizon, as is characteristic of forest soils, has a bad structure and is poor in humus and nutrients. These regions are characterized by an amount of precipitation exceeding the national average, a comparatively favourable distribution of precipitation, a lower average temperature and higher air humidity. With regular fertilization the nutrient capacities of these soils have been substantially improved and as a result the yield averages have been multiplied, even if they have not yet reached the yield levels attained on the naturally most fertile soils. Different types of wheat are needed in these regions than on meadow soils in warmer regions, because, owing to the unfavourable effects of lower spring temperatures, the slow warming up of the soil and other climatic elements which have not yet been completely clarified, wheat varieties of Mediterranean origin can only achieve their high production potentials in years with favourable weather conditions. An excellent example of this was the year 1979. Thus, on these areas the correct proportion of varieties is of basic importance for the development of wheat growing. Among the agrotechnical factors the forecrop, the quality of soil and seed-bed preparation, the optimum sowing date, and weed and disease control are particularly important in these regions.

I think these examples make it clear that no single wheat growing technology can be elaborated which will be uniformly good for the whole of Hungary. Nevertheless, there are general principles which can be relied on when developing local technologies. Let us consider some of these:

It is a well-known fact that the wheat yield is greatly influenced by the forecrop. The less favourable the properties of the soil, the greater the differences in yield between wheats grown after good or poor forecrops. On good soils the difference is often totally negligible. Only a very small proportion of the wheat area of Hungary can be sown after a satisfactory forecrop. A change in this situation on a national scale can hardly be expected in the coming decades, as this would involve a fundamental modification of the crop structure, which is quite impossible. In fact, on examining the wheat forecrop situation of farms attaining the largest yields it is found that wheat is mostly sown after pea, rape or other good forecrops, since these farms are also engaged in the production of peas or seed for sowing. However, on a national scale the present wheat forecrop situation must be expected to continue, so ways in which to reduce the effect of an unfavourable forecrop must be sought. This is not an easy task, though it would certainly help if wheat were not grown more than twice in succession. Within the framework of a uniform national fertilization trial the yield of wheat grown after pea, wheat or maize at various fertilization levels was examined for a number of years. The results show that the disadvantageous effect of the forecrop cannot be counterbalanced even by an optimum rate of fertilization; the difference in yield after good and bad forecrops was about 5 q/ha averaged over the years. It is thus obvious that the wrong forecrop does not only make its effect felt on the yield of the main crop through its influence on the nutrient capacity of the soil.

As was seen from the outline of the wheat growing situation in Hungary, fertilizer utilization has been the main material basis for an increase in production. In spite of the fact that on a national average the phosphorus and potassium balance of the soils is already positive, there are still farms where fertilization does not make up for the loss of nutrients extracted by the plants. If large wheat yields are to be consistently obtained, the phosphorus and potassium supplying capacity of the soil must be raised so as to make the necessary nutritive elements readily available to the plant in the period of intensive growth. And this can only be achieved if readily available nutrients are found in abundance in the 25—30 cm layer of the topsoil. To this end, regular fertilization must be carried out at a level which will not only fulfil the immediate demands of the crop but also enrich the soil.

Of all the plant nutrients it is nitrogen that has the greatest influence on the wheat yield. An optimum or nearly optimum rate of nitrogen application is a fundamental precondition for large wheat yields. Should the amount of nitrogen supplied be either less or more than optimum, the production potential of the variety grown will not be achieved. Besides the nitrogen supplying capacity of the soil and the specific requirements of the variety, the weather conditions during the vegetation period, which are unknown at the time when the rate of fertilization is determined, also modify the optimum dose of fertilizers, so the element of uncertainty which has to be reckoned with is considerable. Methods (spring soil analysis, plant analysis) which enable a closer determination of the optimum rate of nitrogen fertilization to be made are now available, but if they are to be widely applied in practice further investigations will be required.

Mention has been made above of the macro-nutrients which are a general requirement everywhere in wheat growing, but naturally calcium and magnesium nutrition may also become necessary, depending on the local soil conditions.

In Hungary yield losses due to micro-element deficiencies have not been observed in wheat so far. In the future, however, in some soils sooner, in others later, deficiencies of one or more micro-elements must be expected, which will restrict the optimum physiological processes of wheat and thus reduce the yield.

Great hopes were attached to the foliar nutrition of wheat but the experiments carried out in Hungary so far have not verified its efficiency. There may, of course, be circumstances, particularly with soils which are poor in nutrients and have not been given adequate basic fertilization, in which nutritive elements applied in due time through the foliage will influence the yield of wheat to a demonstrable extent. Unfortunately, it is not quite clear what these conditions are, so for the time being the farms use foliar nutrition practically at random, without any scientific basis. When leaf sprays are applied in combination with a plant protection operation the risk is minimal, as the only extra expense involved is the cost of the leaf spray, which is not very high. According to international experience, the higher the level of regular basic fertilization, the less a yield increase can be expected from this method.

The control of wheat lodging is connected with the problem of fertilization. In practice, none of the recommended methods have yielded results. One of the principal objectives of plant breeding is undoubtedly to produce varieties resistant to lodging. In addition, however, good results have been achieved throughout the world with various straw-shortening and straw-strengthening substances. These are particularly needed when fertilizers are applied at the rates optimally required for large wheat yields. As has been seen, in years with certain weather conditions this involves the risk of a considerable yield reduction caused by lodging. With the use of a straw stabilizer the risk will be much less, which may lead to a yield increase of several quintals depending on the crop year. The administrative obstacles to the introduction of this method in Hungary have now been removed, so its wide application may successfully contribute to the development of wheat growing in Hungary.

The importance of the yield components of wheat has recently been studied in numerous experiments. Among these components the number of spikes per unit area and the uniform distribution of spikes deserve special attention under the climatic conditions of Hungary. The trend of these yield components is only slightly dependent on the amount of seed; it is influenced to a much greater extent by the productive tillering ability of the variety, the fertility of the soil, the level of fertilization and the quality of the seed-bed. A favourable number of spikes can be obtained when the seeds are of uniform size and are sown at the same depth in a well-prepared seed-bed.

Quick, even germination is advantageous from the point of view of competition between the plants, too. Satisfactory development of the wheat in autumn is important from the point of view of overwintering. The primary root should penetrate below the frost-line before winter sets in, so that it will be able to take up water even if the winter is long and hard. The development of adventitious roots should also start, in order to protect the plant from being lifted by spring frosts.

It is the task of soil cultivation to produce a root zone with optimum structure and a seed-bed which will enable the plants to emerge quickly and evenly. In the case of wheat a well-settled seed-bed is the decisive factor rather than the depth of soil cultivation. There are so many possible combinations of the factors influencing soil preparation that precise standard procedures cannot be given for all possible cases. Scientific analysis must also be confined to taking the most important factors into account and thus assisting in choosing the correct soil cultivation operations. It was by considering the soil properties, the forecrop, and the moisture content and state of cultivation of the soil that Manninger, Gyárfás, Kreybig and Kemenesy elaborated the major guiding principles which render it possible to produce economically optimum soil conditions for wheat. But unfortunately the implements required to put these principles into practice are not available on many farms.

The yield increase achieved in the last fifteen years was partly due to an annual rise in the area on which wheat was sown on the optimum date. This was mostly a consequence of the development of mechanization. Unfortunately, however, wheat also has to be sown after forecrops which are removed late in the season, which unavoidably involves a delay in sowing.

Although plant breeders attach great importance to disease resistance, as a consequence of the intensive nutrient supply, the resistance even of the new plant varieties is not satisfactory, so in years which are favourable for the spread of diseases chemical control is indispensable, as it will be in the future, too.

The capacity of the combines available for harvesting crops has greatly improved in recent years. Before long it should be possible to reduce the harvesting losses to a minimum by means of harvesting at the optimum time over a short period.

Wheat is one of those plants for which the technology that increases the yield also has a favourable effect on the quality of the crop. Large yields and high quality are not conflicting objectives from an agrotechnical point of view. The situation is different with respect to the varieties. The quality of varieties which produce outstandingly high yields is often unsatisfactory. However, this antagonism does not always occur in practice. For example, the variaties Bánkúti 1201 and Bezostaya 1, which replaced the old wheat varieties in the 1930s and 1960s, respectively, were not only more productive but also of higher quality than the old varieties. The current choice of varieties always includes varieties which are not only highly productive, but which also give flours of a satisfactory quality.

The production of quality-improving wheats which will sell well on the export markets is a different matter. Owing to the geographical position of Hungary, these are primarily the wheats that can be economically exported in the long term. On traditionally good wheat growing areas this can be ensured with suitable varieties. This special quality must, of course, be reflected in the price to a greater extent.

With a view to the future of wheat growing, in addition to improving the technical and material background, the human factor cannot be ignored, as it is man who systemizes the production factors in accordance with the natural and farm conditions, and then puts the system into practice accurately and consistently. This requires experts who will keep in touch with scientific results and practical experience and then adapt and develop these results independently. The education and training at the agricultural universities should be aimed at evolving and strengthening these abilities.

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LECTIONES

PROBLEMS OF SOIL SALINITY AND ALKALINITY IN WATERSHEDS*

The special and characteristic mass and energy regimes of soil types and/or various ecosystem or biogeocoenosis units can only be adequately characterized by describing the various partial processes and subjecting them to integrated evaluation using system analysis. Balance studies of water and salt transport in watersheds and in their different elements play a decisive role in these fields of research.

Salt affected soils, which include both saline and alkali soils, are widely spread in all the continents of our globe. Nearly 10.0% of the earth's continents are covered with salt affected soils. Their extension on different continents is indicated in Table 1 (SZABOLCS 1979).

Studying Table 1 it can be seen that none of the continents is free from salt affected soils. The occurrence of salt affected soils is associated with aridity and practically all arid and semi-arid areas of the world are more or less salinized. The geochemistry of deserts and semi-deserts leads to the accumulation of soluble products in soils and waters, which results in the formation of salt affected soils (ANONYMOUS 1967, KOVDA 1947, WORTHINGTON 1976).

Table 1

Territory of salt affected soils throughout the world (in 1000 ha)

North America	15,755
Mexico and Central America	1,965
South America	129,163
Africa	80,538
South Asia	87,608
North and Central Asia	211,686
South East Asia	19,983
Australasia	357,330
Europe	50,804
Total:	954,832

* Lecture held at the IIASA Conference on "Environmental Management of Agricultural Watersheds", 23–27 April 1979, Smolenice, Czechoslovakia.

Besides deserts and semi-deserts salt affected soils may be found in semi-humid and humid areas as well, particularly in river basins, river deltas, lake and swamp environments. In these conditions, as a rule, alkali soils prevail (Kovda 1947, Szabolcs 1969, 1979).

Since water is the transporting agent for soluble salts on the earth's surface, as well as in the upper layers of the earth's crust, the movement and accumulation of salts correspond to the movement of water. The consequence will be that salt affected soils often occur in watersheds and catchments, whenever the leaching of salts is prevented and favourable conditions come into existence for the accumulation of soluble salts in shallow ground or surface waters, as well as in soil horizons (Darab 1962, Kovács 1960, Szabolcs 1961, Szabolcs—Várallyay 1978, Szabolcs *et al.* 1969a, b, Várallyay 1976, Várallyay—Szabolcs 1974).

Accordingly, saline and alkali soils may be found in deserts and semi-deserts practically anywhere, while in humid conditions the occurrence of salt affected soils is related, in most cases, with hydromorphic processes and is nearly always associated with different elements of a certain watershed.

Agricultural watersheds are often confronted with the problems of soil salinity and/or alkalinity because either the complex structure of the soil cover of the watershed and its existing saline-alkali elements hinder optimal utilization, or — due to extensive agricultural production (mainly irrigation) — adverse soil forming processes, salinization and/or alkalization of soils may develop, sometimes in the most fertile parts of the catchments. A proper knowledge of these processes is necessary if their development is to be predicted and prevented. Without studying, investigating and describing salinization and/or alkalization processes in agricultural watersheds, extensive and up-to-date agricultural management is hardly possible. The salinity status of a certain watershed can decisively determine the possibilities for its agricultural utilization. A prediction of the adverse processes to be expected can considerably contribute to the prevention of their occurrence and development (Anonymous 1976, Szabolcs *et al.* 1969a, 1974, 1976).

As far as the environmental management of agricultural watersheds is concerned, one of the main limiting factors is salinity and/or alkalinity if this occurs inside the watershed and/or in its vicinity. Often so-called potential salinity may exist, that turns into an actual process, mainly due to irrigation (Szabolcs 1979).

The watershed represents an environmental unit in all cases of both recent and potential salinity and/or alkalinity. Evidently, one of the preconditions for the successful utilization and management of agricultural watersheds is a knowledge of salinity and/or alkalinity problems related to the watershed, combined with a fight against these adverse processes.

In order to find a quantitative or semi-quantitative characterization and/or solution for the given soil salinity problems of a certain place, the water and salt balance of the whole watershed must be taken into account (Darab 1962, Darab—Ferencz 1969, Szabolcs 1974, Szabolcs—Darab 1968, Szabolcs *et al.* 1966, 1969b, Várallyay 1967).

From this point of view a detailed analysis of watersheds and catchments of different sizes and shapes is necessary, depending on the aim of the study and the goal of the practical approach.

The territorial units of these system analyses have to be adequately homogeneous, in accordance with the given scale and accuracy level of the investigations. These units may be:

- watersheds of big rivers or large geographical units (i.e. the Danube Plain, or the Carpathian Basin),
- watersheds of smaller rivers (i.e. the Tisza or Zagyva Valley),
- small catchment areas or irrigation systems,
- irrigation areas, geomorphological micro-regions or farming units (agricultural fields),
- soil mapping units, characterized by one or more similar soil profiles.

The methods of modelling or system analysis depend greatly on the size and homogeneity of these units. There are similarities and differences in approach when using analysis of the field water cycle and the salt regime.

Whether salts accumulate or are leached depends on the processes by which they move into, out of, or within the soil profile. These processes can be exactly described, quantitatively characterized and forecasted by salt balances, which can be derived from water balances (Darab 1962, Darab—Ferencz 1969, Anonymous 1967, 1976, Szabolcs 1974, Szabolcs—Darab 1968, Szabolcs *et al.* 1966, 1969b, 1976, Várallyay 1966, 1967, 1970, 1976). They indicate the gains and losses of water or salt in a given unit, over a certain time period and can be written as follows:

$$\text{(incoming quantity)} - \text{(outgoing quantity)} = \text{change of storage in the soil} \tag{1}$$

In spite of their similar character water and salt balances often differ in their factors, composition and application. Salt balances can be calculated:

a) for the total salt content, or for various ions (when studying specific ion effects and chemical changes in the soil solution during filtration),

b) for the whole soil profile from the soil surface to the water table, or for various layers or horizons (when studying salt profile redistribution, hazard of resalinization, leaching efficiency), or for the root zone,

c) for soils, mapping units or territories (if they have a sufficiently homogeneous hydrological character),

d) for vegetation periods, irrigation seasons, seasons, years or longer periods of time (if they have a sufficiently homogeneous hydrological character).

Besides the general salt balance, detailed or factorial salt balances have to be established, too, reflecting not only the integrated changes but also revealing the causes of the changes and quantitatively characterizing the partial contribution of various factors in these changes. In this way the potential possibilities of proper salinity-alkalinity control (man-controlled salt balance regulations; the prevention, moderation or halting of processes increasing the salt reserve; the promotion or introduction of processes reducing the salt reserve) can be determined; a prognosis can be given for the natural salinization and alkalization processes, and the probable effect of various human interventions, e.g. land use, agrotechnics, amelioration, irrigation, leaching, drainage, control of flooding, seepage and run-off, etc., can be predicted to a certain extent as well. On this basis the necessity, effectivity and efficiency of a given measure can be evaluated, the most favourable variant(s) can be selected and realized, and proper technologies can be elaborated for this purpose.

The general equation for detailed (factorial) salt balances can be written as follows:

$$\Delta S = (P + I + R + G + W + F) - (l_p + l_i + r + g + n) \tag{2}$$

where:

ΔS = Salt balance

P = Quantity of salts derived from the atmosphere (airborne salts, rainfall, wind action, etc.)

I = Quantity of salts added with the irrigation water

R = Horizontal inflow of salts transported by surface waters (run-off, flood, water-logging)

G = Horizontal inflow of salts transported by subsurface waters (ground-waters, deep subsurface waters, etc.)

W = Quantity of salts derived from local weathering processes

F = Quantity of salts added with fertilizer and chemical amendments
l_p = Quantity of salts leached out by atmospheric precipitation
l_i = Quantity of salts leached out by irrigation (leaching) water
r = Horizontal outflow of salts (discharge) transported by surface waters
g = Horizontal outflow of salts transported by subsurface waters (drainage)
n = Quantity of salts taken up by plants and transported from the area with yield.
All factors can be given in the dimension t/ha.

P, I, F and n can be measured and predicted easily; R and r can be estimated on the basis of topographical surveys, meteorological observations, surface water investigations and infiltration studies; G and g can be calculated from ground-water characteristics, taking into account the hydrophysical properties of the soil layers between the soil surface and the water table; l_p and l_i can be estimated on the basis of data on these hydrophysical properties, on the flow rate of downward filtration and on the chemical composition of the filtrating solutes, or they can be determined experimentally in leaching studies; W can be estimated by evaluation of factors influencing local weathering, the transport and transformation of the weathering products.

The probability and accuracy of such salinity and alkalinity prognoses depend on the homogenity (from the viewpoint of hydrological and soil conditions) of the area surveyed and the reference period studied and on the quantity, quality, probability, accuracy, processability and interpretability of the available data and information concerning the soil and hydrological characteristics (SZABOLCS *et al.* 1976).

In Tables 2 and 3 factorial salt balances are given for various non-irrigated and irrigated soils in Hungary (SZABOLCS *et al.* 1969b).

A simple, easily applicable and expressive form of the "analytical" salt balance is the "salt regime coefficient":

$$d = b - (a + c) \tag{3}$$

where:

d = salt regime coefficient, t/ha
b = quantity of salts at the end of the reference period, t/ha
a = quantity of salts at the beginning of the reference period, t/ha
c = quantity of salts added by the irrigation water, t/ha.

Since $(b - a)$ is the salt balance (ΔS), $d = \Delta S - c$.

As can be seen from Tables 2 and 3 the possible combinations of ΔS and d can be interpreted as follows:

(i) Both ΔS and d are negative values (e.g. Profile 8). This means that the quantity of salts decreased under the influence of irrigation ($c < d$)

(ii) ΔS is positive, d is negative [e.g. Profile 11 in Table 2 or Periods (4) and (8) in Table 3]. This means that the natural leaching could not balance the quantity of salts given with the applied irrigation water ($d < c$). In such a case the main reason for the salt accumulation is irrigation. There are two possibilities for the prevention of salt accumulation: decreasing "c" (a lower quantity or better quality of irrigation water has to be applied), or increasing "d" (improvement of drainage conditions → better environment for natural leaching).

(iii) Both ΔS and d are positive [e.g. Profiles 9, 10 and 13 in Table 2 or Periods (1), (2) and (7) in Table 3]. In such cases besides the irrigation water there is another source of water-soluble salts, namely the ground-water. Consequently, the prevention of salt accumulation requires ground-water regulation and/or further ameliorative measures.

Table 2

Total salt balances of soils in Hungary

Profile No.	Thickness of the profile, cm	Total quantity of water-soluble salts at the beginning of the reference period	Total quantity of water-soluble salts at the end of the reference period	Factors resulting in an increase in the quantity of soluble salts: ground water	Factors resulting in an increase in the quantity of soluble salts: irrigation water	Factors resulting in an increase in the quantity of soluble salts: Total	Factors resulting in a decrease in the quantity of soluble salts: leaching form the amount added with irrigation water	Factors resulting in a decrease in the quantity of soluble salts: leaching form the original salt content of the soil	Factors resulting in a decrease in the quantity of soluble salts: Total Σ"+"	Salt balance	Salt regime coefficient
		a	b	g	c	Σ"–"				ΔS	d
		tons/ha									
					Under natural conditions (Transtisza region)						
1.	150	42.58	33.07	—	—	—	—	9.51	9.51	−9.51	−9.51
2.	150	57.69	56.78	—	—	—	—	0.91	0.91	−0.91	−0.91
					(Between the Danube and Tisza rivers)						
3.	260	22.79	26.08	3.29	—	3.29	—	—	—	+3.29	+3.29
4.	250	28.71	30.97	2.26	—	2.26	—	—	—	+2.26	+2.26
5.	240	66.93	70.12	3.19	—	3.19	—	—	—	+3.19	+3.19
6.	200	62.46	65.08	2.62	—	2.62	—	—	—	+2.62	+2.62
7.	200	43.21	40.21	—	—	—	—	3.00	3.00	−3.00	−3.00
					Under irrigated conditions (Transtisza region)						
8.	150	33.28	26.02	—	0.21	0.21	0.21	7.26	7.47	−7.26	−7.47
9.	150	141.23	144.50	2.49	0.78	3.27	—	—	—	+3.27	+2.49
10.	150	45.16	60.47	2.31	13.00	15.31	—	—	—	+15.31	+2.31
					(Between the Danube and Tisza rivers)						
11.	190	29.38	37.11	—	9.60	9.60	1.87	—	1.87	+7.73	−1.87
13.	230	37.11	42.24	2.82	2.31	5.13	—	—	—	+5.13	+2.82

Table 3

Factors in the salt balance of an irrigated

Reference period	Total quantity of water soluble salts, at the beginning of the reference period, t/ha	end	$\frac{b}{a}$
	a	*b*	
(1) June 1961—June 1963	36.96	53.42	1.44
(2) June 1963—May 1964	53.42	60.86	1.14
(3) May 1964—June 1965	60.86	45.79	0.75
(4) June 1961—June 1965	36.96	45.79	1.23
(5) May 1964—June 1964	60.86	48.56	0.88
(6) Nov. 1961—June 1965	48.56	45.79	0.94
(7) June 1961—May 1964	36.96	60.86	1.63
(8) June 1961—Nov. 1964	36.96	48.56	1.31

If "d" is known, the maximum quantity of salts that can be given by the irrigation water without any salt accumulation can be calculated as follows:

Since $c = \Delta S - d$, when $\Delta S = 0$, $c = -d$.

If the quantity of irrigation water required for the water supply of crops is known, the permissable maximum concentration of irrigation water can be determined as well (Szabolcs *et al.* 1969b).

It is quite obvious from the above that the main factors of salt accumulation in irrigated soils are:

1. Water-soluble salts accumulate from saline or brackish irrigation water.
2. The water table rises and so:
   a) the salt content of the ground-water accumulates in the affected layers, the subsurface waters accumulate the soluble weathering products from large areas and extensive watersheds into relatively small, depressed lowlands;
   b) the rising ground-water transports (transmits) the soluble salts from deeper subsurface waters, geological deposits or soil layers into the overlying horizons, i.e. to the surface layers; or
   c) the stagnant ground-water limits the natural drainage of the area and impedes the leaching of salts derived from local weathering or irrigation water.
3. The periodical wetting and drying of the soil promote the weathering processes and the soluble weathering products increase salt accumulation.

Irrespective of its source, all irrigation water contains dissolved salts, the kind and quantity of which depend on its origin and also its course before use. The criteria for assessing the suitability of water depend on the specific conditions of use, including land use, cropping pattern, salt tolerance of crops, various soil properties (especially vertical and horizontal drainage), climatic conditions, irrigation management, agrotechnics, etc. (Darab 1962, Darab—Ferencz 1969, Darab—Szabolcs 1960, Anonymous 1967, 1976, Szabolcs 1961, Szabolcs—Darab 1968, Szabolcs *et al.* 1966, Várallyay 1967, 1976, Worthington 1976).

Ground-water is an important factor of the general water balance, as well as of the field water cycle (Anonymous 1967, 1976, 1978, Kovács 1960, Kovda 1947, Talsma 1963, Várallyay 1975).

meadow soil in the Hungarian Danube Valley

Factors resulting in an increase in the quantity of water-soluble salts					Leaching	Salt balance, ΔS	Salt regime coefficient, d
Irrigation water			ground water	Σ"+"			
quantity applied, mm	salt-concentr., g/l	quantity of slats (c)					
		t/ha					
250	6.3	15.75	0.71	16.46	—	+16.46	+ 0.71
60	6.3	3.78	3.66	7.44	—	+ 7.44	+ 3.66
—	—	—	—	—	15.07	−15.07	−15.07
310	6.3	19.53	4.37	23.00	15.07	+ 8.83	−10.70
—	—	—	—	—	12.30	−12.30	−12.30
—	—	—	—	—	2.77	− 2.77	− 2.77
310	6.3	19.53	4.37	23.90	—	+23.90	+ 4.37
310	6.3	19.53	4.37	23.90	12.30	+11.60	− 7.93

In a general form, the ground-water balance may be expressed as follows:

$$(P + S_i + G_i + H_i) = (E + T + S_0 + G_0 + H_0) \tag{4}$$

where:

P = Precipitation filtrating to the ground-warer
S_i = Surface waters (rivers, streams, lakes, ponds) filtrating to the ground-water
G_i = Ground-water inflow from the neighbouring areas
H_i = Human-induced recharge from irrigation, reservoirs, spreading operations and injection wells
E = Evaporation
T = Transpiration
S_0 = Ground-water outlow to surface waters (rivers, streams, lakes, ponds)
G_0 = Ground-water outflow to the neighbouring areas
H_0 = Human-induced discharge by pumping or flowing wells or drains.

Depending on the importance of the various factors, various types of ground-water regime can be distinguished. These are schematically summarized in Table 4, indicating their characteristics and practical consequences. On this basis the possibilities of appropriate ground-water control can be determined and methods can be elaborated for their realization.

The ground-water is the main salt source particularly in low-lying, poorly, or very poorly drained areas (closed basins, lowlands, low alluvial terraces and delta areas, etc.), where its horizontal flow is very low (low slope gradient, hydraulic gradient and generally very low hydraulic conductivity) and this "stagnant" character affords a potential possibility of gradual concentration. The water table is near the surface, so the capillary flow can transport relatively large quantities of water and soluble salts to the overlying horizons, to the active root zone. Under such conditions salt-affected soils may develop not only in arid regions but also under relatively humid climates (SZABOLCS *et al.* 1969a).

If neutral sodium salt ($NaCl$, Na_2SO_4) accumulation takes place in coarse textured soils the salinization is a more or less reversible process. In such cases the salts accumulated by irrigation during the vegetation period can be washed out from the soil profile by leaching

Table 4

Main types of groundwater regime, their characteristics and practical consequences

<table>
<tr><th>Type</th><th>Sub-category</th><th colspan="2">Practical consequences</th></tr>
<tr><td rowspan="5">A) Stabilized, compensated
$\Delta G \approx 0$
↓
water table stable</td><td>a) Compensated by subterranean outflow; $G_i = G_0$</td><td colspan="2">Desalinization, little danger of secondary salinization</td></tr>
<tr><td>b) Compensated by subterranean outflow and transpiration: $G_i = G_0 + T$</td><td colspan="2">Desalinization; $CaCO_3$ and $CaSO_4$ may accumulate in subsoil; secondary salinity may occasionally occur</td></tr>
<tr><td>c) Compensated by subterranean outflow, transpiration and evaporation: $G_i = G_0 + T + E$</td><td colspan="2">Slight salinization with accumulation of Na_2CO_3, Na_2SO_4; if methods of farming are poor, there may be strong salinization</td></tr>
<tr><td>d) Compensated by transpiration and evaporation: $G_i = T + E$</td><td>Strong</td><td rowspan="2">progressive salinization with accumulation of large quantities of NaCl, Na_2SO_4, $MgCl_2$, $MgSO_4$</td></tr>
<tr><td>e) Compensated by evaporation: $G_i = E$</td><td>Very strong</td></tr>
<tr><td rowspan="2">B) Non-stabilized, over-compensated
$\Delta G > 0$ ("+")
→rising water table</td><td>a) Over-compensated by increase in feeding (seepage): $G_i > G_0$</td><td colspan="2" rowspan="2">When the ground-waters reach the critical level, an intensive, rapid process of salinization sets in, sometimes complicated by water-logging</td></tr>
<tr><td>b) Over-compensated by decrease in outflow (poor drainage): $G_i > G_0$</td></tr>
<tr><td rowspan="2">C) Non-stabilized, under-compensated
$\Delta G < 0$ ("−")
→sinking water table</td><td>a) Under-compensated owing to decrease in feeding (seepage control): $G_i < G_0$</td><td colspan="2">With ground-waters near and above the critical level: limited decrease in salinity; with ground-waters below the critical level: desalinization</td></tr>
<tr><td>b) Under-compensated owing to increase in outflow (good drainage): $G_i < G_0$</td><td colspan="2">Desalinization, increasing as the water table drops</td></tr>
</table>

and removed from the area by horizontal drainage. This is a widely used practice in many parts of the world (Central Asia, North Africa, Near East region, USA). But this is a rather expensive procedure and has to meet the following requirements:

adequate amount of good-quality water (leaching requirement, leaching fraction),

good vertical drainage of the soil profile (light textured, permeable soils with chloride-sulphate type salinization and low Na^+ saturation),

good horizontal drainage of the area (high rate of horizontal ground-water flow),

frost-free season over the vegetation period,

drain-water reservoir with adequate storage capacity.

Under these circumstances there are two possibilities for efficient salinity control: 1. prevention of salt accumulation, and 2. maintenance of the salt balance in equilibrium by leaching and drainage (ANONYMOUS 1967, KOVDA 1947, SZABOLCS 1979, VÁRALLYAY 1976, WORTHINGTON 1976).

The ion components and their concentrations in the soil absorption complex are formed due to the existing equilibrium between the solid and liquid phases in the soil. The Na^+ saturation of the absorption complex (ESP value) depends on the absolute and relative concentration of Na^+ ions in the soil solution, which is determined by the quantity and solubility of sodium and other salts in the soil. In the presence of sodium salts capable of alkaline hydrolysis most of the Ca and Mg salts are in precipitated form, and only the more soluble Na salts remain in solution and migrate within the soil profile: the Na^+ cation thus becomes absolutely dominant. This results in a high Na^+ saturation even at a relatively low salt concentration (DARAB—FERENCZ 1969, DARAB—SZABOLCS 1960, SZABOLCS 1961, 1969, 1974). The high Na^+ saturation of soil colloids brings about unfavourable changes in the physical and hydrophysical properties of soils (VÁRALLYAY 1976, VÁRALLYAY—SZABOLCS 1974). These processes are not reversible, so they cannot be controlled and balanced by simple leaching, and in most cases the reclamation of the secondary alkaline soils is possible only by very expensive complex amelioration methods. Therefore, the most economic solution for proper alkalinity control is prevention (ANONYMOUS 1976, SZABOLCS *et al.* 1969a).

To give an exact quantitative description of these processes a comprehensive system of mathematical modelling was developed by a team working as part of the co-operation programme between the USSR and the Hungarian Academy of Sciences (KOVDA—SZABOLCS 1979).

Salinity problems in watersheds differ depending on their shape and size as well as on their geological, geochemical and hydro-geological conditions:

1. Alluvial territories. A geomorphological cross-section of this sort in shown in Fig. 1.

Before flood-control the greater part of the valley was flooeded during the high-water period of the river and the soil-forming process was repeatedly interrupted by these floods (resulting in periodical sedimentation of the suspended fine sand, silt and clay, as well as retransport of the previous sediments and disturbances in the original stratification of the alluvial parent material). Consequently, there was little or no possibility for the development of a characteristic soil profile with its diagnostic horizons: these areas are covered by various alluvial soils. After flood-control these conditions remain only within the floodplain (between the dikes), while on the other territories — depending on the time which has elapsed since the last flood or sedimentation — a special "chronosequence" of soils occurs, and the various stages of the formation of zonal and azonal soil types (under the influence of the other soil-forming factors) can be distinguished.

In Hungary there are two main possibilities in this respect:

(i) in the case of a high water table with low salinity, having a permanent influence on the soil-forming processes (alluvial terraces covered by medium or heavy-textured sediments, e.g. the Hungarian Tisza Valley) this chronosequence is: row alluvium → alluvial soil → humous alluvial soil → meadow alluvial soil → alluvial meadow soil → meadow soil.

(ii) in the case of no (or negligible) ground-water influence (well-drained alluvial terraces with deep water table, or with ground-water standing in the gravelly strata, e.g. the alluvial fan of the Danube in NW Hungary) this chronosequence is: row alluvium → alluvial soil → humous alluvial soil → chernozem-like alluvial soil → terrace chernozem.

These possibilities are schematically illustrated in Fig. 1.

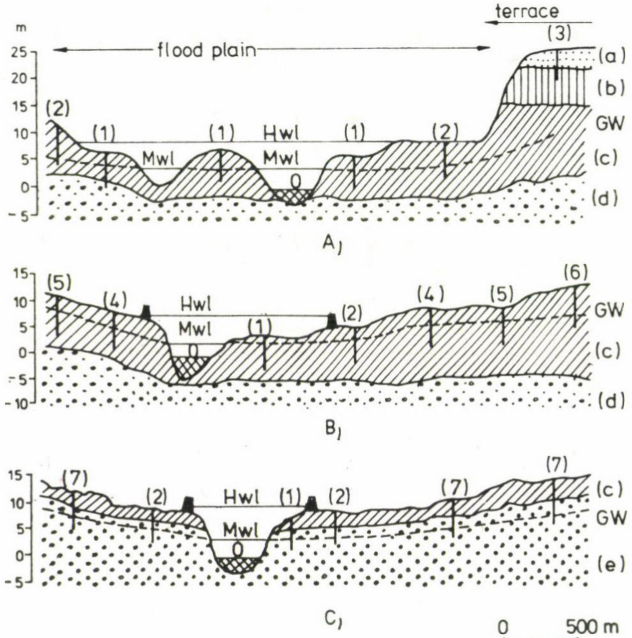

Fig. 1. Soil formation in various flood-plains [schematic cross section, *A)* before flood-control, *B)* and *C)* after flood-control, 1. alluvial soil, 2. humous alluvial soil, 3. chernozem, 4. alluvial meadow soil, 5. meadow soil, 6. meadow chernozem, 7. terrace chernozem, *a)* aeolian sand, *b)* loess, *c)* fine-textured alluvium (clay, silt, fine sand), *d)* coarse-textured alluvium (coarse sand, gravel), *e)* gravel, GW = water-table]

2. Lowland areas with heterogeneous microrelief and low ground-water salinity. In such territories a special hydromorphic soil sequence can be observed, depending on the expression of the ground-water influence, which is determined mostly by the micro- or mezo-toposequence. A peat → peaty meadow soil → meadow soil → chernozem-meadow soil → meadow chernozem → "lowland-chernozem" → chernozem

hydromorphic soil and toposequence of this type is shown in Fig. 2.

3. On territories with saline and/or alkaline ground-water the above-mentioned soil processes are combined with salinization and/or alkalization, which result in the development of various salt-affected soils.

Such a typical area is the Hungarian Plain, where the extension of salt-affected soils exceeds 20–25% of the total arable land and there exists a potential hazard of salinization and/or alkalization in almost the whole region. The Hungarian Plain is the bottom of the geologically, geomorphologically, hydrologically and hydrogeologically closed Carpathian Basin, where the climate is semi-humid. The annual potential evaporation (750–850 mm) exceeds the annual precipitation (550–650 mm) and during the summer months there is a considerable water deficit in the water balance. The main causes of the actual and potential

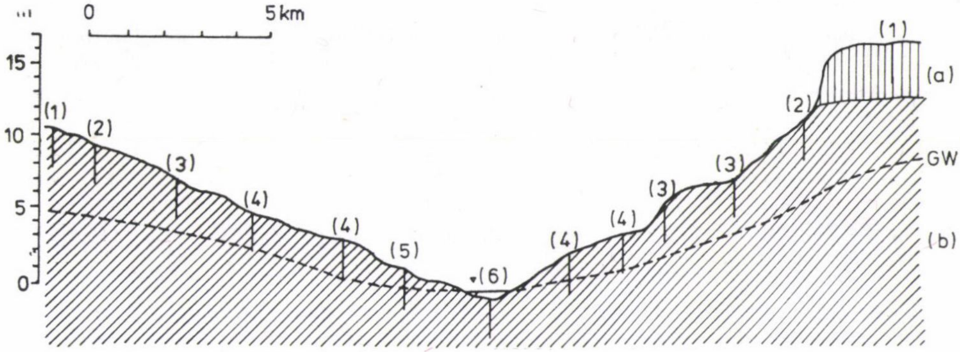

Fig. 2. Toposequence of soils in a medium-size watershed [1. chernozem, 2. "lowland chernozem", 3. meadow chernozem, 4. meadow soil, 5. peaty meadow soil, 6. peat, *a)* aeolian loess, *b)* fluviatile-aeolian loess-like deposits, GW = water table]

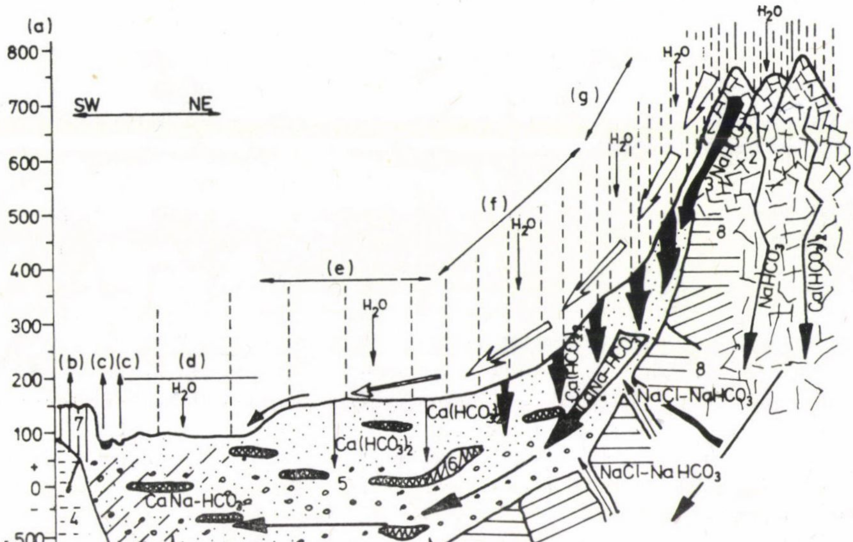

Fig. 3. The process of salt accumulation in the Hungarian Danube Valley [*a)* height above sea level m, *b)* Trans-Danubian loess plateau, *c)* Danube, *d)* Danube Valley, *e)* Sand ridge between the Danube and the Tisza, *f)* Basin periphery, *g)* Hungarian central range of mountains, 1. limestone, 2. rhyolite, andesite, 3. rhyolite and andesite tuff, 4. impermeable pannon clay, 5. fluviatile gravel, sand, sandy silt, 6. clay lens, 7. loess, 8. pleistocene clay. The direction of the arrows indicates the direction of water movement, while their width shows the amount of water. The width of the black arrows and the size of the chemical symbols indicate the degree of salt content increase]

salinization and alkalization processes are: the closed character of the Carpathian Basin, thick salty Tertiary and Quaternary layers in the geological profile, and stagnant, salty ground waters with a shallow (or, dur to very poor natural drainage, easily and rapidly rising) water table (SZABOLCS 1961, SZABOLCS *et al.* 1969a, VÁRALLYAY 1967, 1968, VÁRALLYAY—SZABOLCS 1974).

In Fig. 3 a schematical cross section of the Hungarian Danube Valley is given, illustrating the salt accumulation processes (VÁRALLYAY 1967, 1968). Some of the precipitation falling on the extensive catchment areas filtrates into the soil. During its downward movement it percolates through various soils and geological deposits and by dissolving some of their soluble weathering products its salt content increases. These slightly saline subsurface waters of Ca and/or Na bicarbonate type (according to the geochemical character of the watershed) accumulate in the large, "stagnant" ground-water basin of the Danube Valley (Fig. 3). These ground-waters are the main actual and potential salt sources in the area.

The occurrence of the soil types depends on their distance from the Danube, on the time which has elapsed since they were flooded, and on the depth of the water table, which is determined by the relief (see Table 5).

Table 5

Relief, soil type, average depth of water table and chemical composition of the ground-water in the Hungarian Danube Valley

Soil type	Height above sea level, m	Average depth of the water table, m	Salt content of ground water, g/l	Salt composition of ground-water
Recent alluvial soil	94— 97	2—2.5	0.3— 0.5	$Ca-HCO_3$
Meadow chernozem	97—100	3—4	1.0— 2.0	$Na(Ca)-HCO_3(Cl)$
Meadow soil, meadow alluvial soil	95— 97	2—3	1.0— 2.0	$Na-HCO_3$
Solonchak-solonetz	94— 95	1—2	2.0— 5.0	$Na-HCO_3$
Calcareous-solonetz	94— 95	1.5—2.5	2.0— 3.0	$Na-HCO_3$
Solonchak	93— 94	0.5—1.2	5.0—10.0	$Na-HCO_3(Cl)$

From the first condition, the following sequence of soils may be found: recent alluvial soils → humous alluvial soils → alluvial meadow soils → meadow soils, while the depth of water table suggests the following hydromorphic series: chernozem → meadow chernozem → meadow soil → peaty meadow soil → bog soil. Furthermore, there also exist solonchak (or saline), solonchak-solonetz (or saline-alkali) and calcareous, solonchakous (or salinized) meadow solonetz soils (Fig. 4).

The possibility of salinization from the ground-water is determined by the dominant vertical direction of water flow and salt transport through the soil profile above the water table. The quantity of salts entering the soil profile from the ground-water is determined by the quantity (Q_S) and concentration (C_S) of the soil solution transported by capillary forces from the ground-water to the overlying horizons. C_S depends on the concentration, chemical composition and solubility of the salt content of the ground-water, on the changes in the concentration and chemical composition of the solution during the upward capillary flow and on the interactions between the solid and liquid phases of the soil. Q_S is determined by the direction and velocity of the capillary flow (which is a function of the suction profile, the

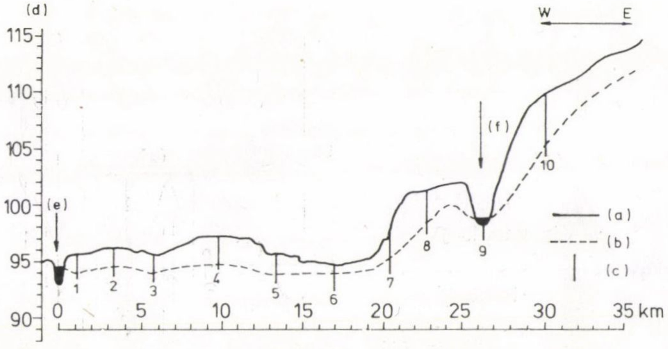

Fig. 4. Correlation of relief, average depth of water table and genetic soil type in the Hungarian Danube Valley [*a)* soil surface, *b)* water table, *c)* location of profiles, *d)* height above sea level m, *e)* Danube, *f)* temporary water-logging, 1. Recent alluvial soil, 2. Humous alluvial soil, 3. Calcareous solonchakized, shallow meadow solonetz, 4. Meadow alluvial soil, 5. Solonchak-solonetz, 6. Solonchak, 7. Solonetzic meadow soil, 8. Humous sandy soil, 9. Marshy meadow soil, 10. Humous sandy soil]

capillary conductivity and the depth of the water table). For the quantitative characterization of these relationships the unsaturated flow theory can be applied (TALSMA 1963, VÁRALLYAY 1974a, 1974b, 1975).

There is a certain depth of the water table at which the salt balance of the soil profile between the soil surface and the water table is in equilibrium: the quantity of salts transported from the ground-water to the overlying horizons equals the quantity of salts transported from the soil profile to the ground-water. This is defined as the "critical depth" (SZABOLCS *et al.* 1969a, 1974). If the actual water table is below this level the downward flow is predominant and leaching takes place. If the actual water table is above this level the upward flow dominates, resulting in salt accumulation. The distribution of the various salts in the soil profile is determined by their solubility. These processes are schematically illustrated in Fig. 5 (VÁRALLYAY 1967, 1968).

In salt affected areas the intense evaporation of stagnant ground-waters near the surface is not hindered — or only for a very short time — by waterlogging during the summer. Considerable salt accumulation and alkalization is prevented where waterlogged conditions occur, and where the water table is below the critical level, as in chernozem, meadow chernozem and sandy soils, and also where sharp fluctuations in the ground-water occur, as in the alluvial soils along the Danube (Fig. 4).

Based on many-sided hydrophysical and physico-chemical studies DARAB *et al.* (1973) and SZABOLCS *et al.* (1969a, 1974) elaborated various approaches to the exact determinations of this "critical depth", taking into consideration numerous soil and hydrological factors.

VÁRALLYAY (1974a, 1974b) elaborated a four-step hydrophysical model for the more exact and accurate determination of the "critical depth" or "critical regime" of the ground-water, in the case of layered soil profiles with rising (or fluctuating) water tables.

In recent years a comprehensive salinity-alkalinity prognosis system has been established in Hungary (DARAB *et al.* 1973, SZABOLCS 1979, SZABOLCS *et al.* 1969a, 1974, 1976, 1977, SZABOLCS—VÁRALLYAY 1977).

This system consists of two steps:

— preliminary (small or medium scale) reconnaissance survey and mapping,

— detailed (large scale) survey and mapping.

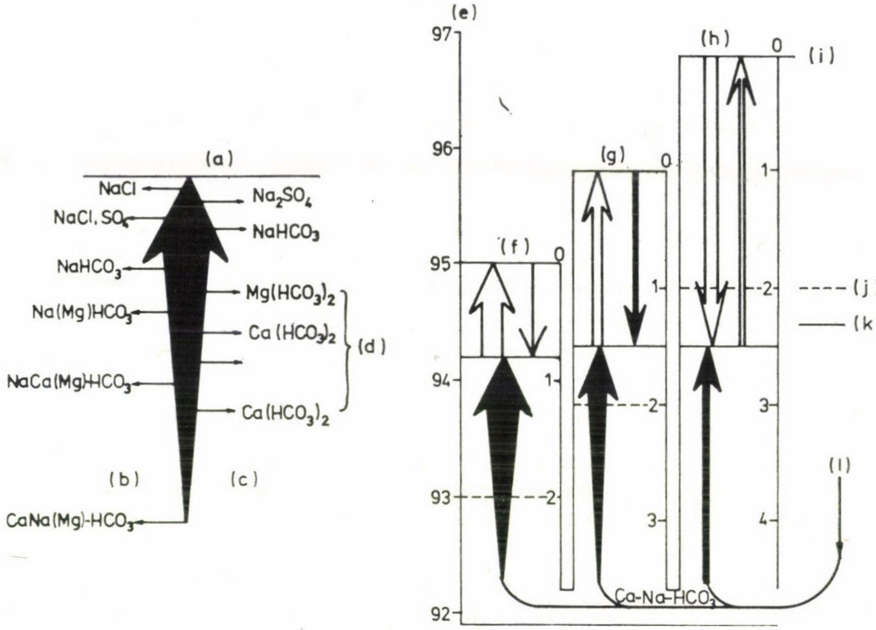

Fig. 5. Schematic diagram of salt accumulation in the Hungarian Danube Valley [*a)* change in the chemical composition of water during concentration, *b)* chemical composition of the soil solution, *c)* sequence of the precipitation of salts, *d)* carbonate accumulation horizon, *e)* height above sea level m, *f)* intense salt accumulation on the surface (solonchak soils), *g)* salt accumulation near the surface (solonchak-solonetz soils), *h)* leaching (meadow and meadow alluvial soils), *i)* soil surface, *j)* equilibrium (critical) level of water table, *k)* actual level of water table, *l)* hydrostatic pressure. The direction of the arrow indicates the direction of water and salt movements. The width of the white arrows is proportionate to the intensity of water movement, while that of the black arrows is proportionate to the salt content of the water]

The reconnaissance-type, low intensity surveys (on the scale 1 : 100,000, 1 : 200,000, 1 : 500,000, for example) cannot be limited to the project area, but have to be extended for the whole geographical unit (water catchment area, hydrological region, irrigation system, etc.). This survey has to be extended to the soil characteristics (soil types, parent materials, salinity-alkalinity status of soils, existing and potential soil-forming factors and soil processes) and the environmental factors (especially climatic and hydrologic conditions).

Based on an integrated analysis of these factors a map was constructed by Szabolcs *et al.* (1969a, 1974, 1976) and Darab *et al.* (1973), on the scale 1 : 100,000, indicating the general possibilities of efficient salinity-alkalinity control, the prevention of secondary salinization and alkalization processes, and the preconditions of effective irrigation from the viewpoint of soil conditions. Three categories were distinguished:

1. Areas to be irrigated. In these areas irrigation will not result in soil processes leading to a decrease in soil fertility or adversely affecting the soil properties, when:
   a) irrigation water of good quality is applied,
   b) no significant changes in environmental conditions occur in the whole geographical region.
2. Areas to be irrigated conditionally. The conditions for irrigation in these areas are to prevent the processes of waterlogging, secondary salinization and alkalization by

keeping the ground-water table below the critical depth and by using irrigation water of "good quality".

3. Areas not to be irrigated. In these areas irrigation is not advisable for the time being, because it would result in the development or intensification of undesirable hydrological and soil processes. To prevent these processes expensive technical and ameliorative measures are required.

Apart from a general knowledge of the factors and processes influencing the present and future salinity and alkalinity status of soils over a large area (water catchment area, ecological region, irrigation network, etc.), more precise soil and hydrological surveys are necessary for the detailed description of salinization and alkalization and reverse processes, in order to be able to make a more exact and accurate analysis of the factors influencing them and the possibilities of controlling them.

For this purpose a method for a more detailed survey system was elaborated, including the preparation of a series of maps on a scale of 1 : 25,000.

The following maps were prepared:

Soil map. This map indicates the soil type and subtype and shows a general picture of the existing soil processes. The map is necessary for the interpretation and evaluation of soil properties and for forecasting prospective changes in soil conditions due to irrigation.

Map of soil texture and water properties. This map indicates the soil textural classes and the categories of soil water properties.

Map of salinity status. This map indicates the average total salt content in the soil between the surface and the water table (as a percentage), the maximum total salt content of the soil profile (as a percentage), the depth to the salt maximum in the soil profile (in cm) and the pH of the B-horizon (pH below and above 8.5).

Map of ground water conditions. This map indicates the average depth to the water table (in metres), the average salt content of the ground water (in g/litre) and the sodium percentage in the ground water.

On the basis of the above-mentioned maps two more maps were prepared on the same scale (1 : 25,000):

Map of the "critical depth to the water table". This map indicates this calculated parameter in metres.

Map of the possibilities and preconditions of irrigation. First this map shows the possibilities of effective irrigation from the viewpoint of detailed soil conditions. Using the same evaluation basis as was used for the general map (1 : 100,000) the following areas were distinguished on the 1 : 25,000 scale map:

I. Areas to be irrigated;
II. Areas that may be irrigated conditionally;
III. Areas not to be irrigated.

Secondly, this map indicates the following ground-water control measures that must be taken to prevent salinization and alkalization processes due to irrigation:

A) Lowering of the water table;
B) Prevention of a rise in the water table;
C) Regular study of the water table.

In addition to the above-mentioned information the map gives some general directives concerning irrigation:

1. Frequent irrigation is advisable with low water application rates.
2. Medium frequent irrigation is advisable with medium water application rates.
3. One (or infrequent) irrigation is advisable with high application rates.

Using the method described, 1 : 25,000 scale maps were prepared for most of the Hungarian Plain.

This prognosis system was successfully used for the planning and operating of Tisza irrigation systems and it afforded the practical possibility of preventing soil deterioration due to salinity and alkalinity in the Hungarian Plain.

The general approach to salinity and alkalinity prognosis is similar in any region, but the influencing factors and especially the limiting values are, of course, different, and should be studied and determined according to the local conditions (SZABOLCS *et al.* 1976). The environmental management of agricultural watersheds needs both rational agricultural practices and well-founded exploitation of the environmental factors, with particular regard to the protection of the environment as a whole. Soil salinity and/or alkalinity has a very intensive influence on the possibilities for the agricultural utilization of watersheds. At the same time, the salinity and/or alkalinity of soils and waters constitute the kind of environmental factors that may damage the biosphere and threaten the life conditions and development of plants, animals and human beings. The complex and coordinated study and description of the processes mentioned are of vital importance for the future. In the forthcoming years coordinated investigations on the applied system analysis for the main processes of salinization of soils and waters will have theoretical and practical significance. For this reason they must be encouraged and supported both at a national and international level.

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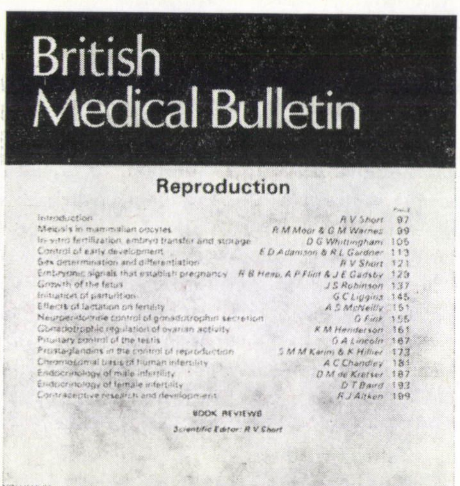
RECENSIONES

"*Reproduction*". British Medical Bulletin, vol. 35, No. 2. May 1979. Ed. R. V. Short.

One of the great problems affecting humanity in the 20th century is, without any doubt, overpopulation. The question is fundamentally a biological one, or to be more precise: a problem of reproduction biology, and as such it goes far beyond the scope of human biology and concerns all forms of life on the Earth. The solution of the pressing problem of overpopulation is expected to come partly through settling the social questions, but chiefly from science. This expectation is perfectly justified, and scientists have a due sense of responsibility and devotion to their work. Nevertheless, the extremely complex nature of the question, the relative backwardness of the social consciousness (particularly in the countries most affected) and the biological disorders in embryonal development caused by various types of intervention exhort to caution and moderation. When surveying the international situation in reproduction biology research both positive and negative phenomena are found. The scattered investigations which had been made up to the 1970s were placed under the authority of WHO in 1972 and a wide-ranging theoretical and practical programme was launched to solve questions of human reproduction biology. In the course of evaluating the programme all the fundamental theoretical deficiencies which still exist in the field of reproduction biology and can only be cleared up even approximately after long years of extensive investigations, soon came to the fore. The initial impetus was broken; those countries which were best qualified to carry out research in this field became aware of the fact that the problem was not really the greatest problem in their own case, and gradually the view has developed that the question should be solved by those primarily concerned: the developing countries. Fortunately, there is no lack of responsible efforts. In this respect the volume of the British Medical Bulletin published in May 1979 gives a good example by summarizing 16 papers on the present status, current



British
Medical Bulletin

Reproduction

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BOOK REVIEWS

Scientific Editor: R V Short

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problems and future tasks of human reproduction biology on some 100 pages.

The primary task of reproduction and birth control is no doubt to prevent overpopulation. Yet, in many cases childless parents are the ones who need help to have children. Whether it is fertility or infertility which is aimed at, both can be solved only on a strictly scientific basis, fully relying on the most recent information available or expected to be available soon in the field of reproduction biology. This is the train of thought expressed in the articles included in the British Medical Bulletin. The first articles sum up the most recent knowledge on the physiological process of fecundation. Special importance is attached to the control of meiosis in the mammalian ovum, in which, apart from the gonadotrophines, the steroids play a significant role, according to the most recent data (Moor—Warnes 1979). The attempts to bring about fecundation under well controlled *in vitro* conditions are highly promising. This is of great importance not so much in humans as in practical animal breeding, where a much larger number of progeny can be produced *in vitro* than under the conventional conditions. This method is of enormous significance in the case of breeding animals with high economic value. Besides rabbits and rats the human ovum has also been successfully fertilized (Steptoe—Edwards 1978, p. 111). The early development stage of the young 3—10 days old human embryo is relatively little known; data are mostly available for rabbits and mice. There are a lot of more data, on the other hand, on the development of sex and the subsequent process of differentiation (R. V. Short, pp. 121—127). Nevertheless, the possibility of actually exercising a primary influence on the sex reatio is for the time being merely a dream. Although the main emphasis in the British Medical Bulletin is on humans, mention is also made of the major "embryonic signals" which control the maternal endocrine functions of domesticated animals (R. B. Heap *et al.*, pp. 129—135). Experiments on this subject are mainly carried out with domesticated animals (pigs, sheep, cattle), so they open up new prospects in practical animal breeding by creating a theoretical basis for the successful maintenance of pregnancy. According to the results of investigations over the past 20 years the intrauterine growth of the human embryo is retarded in a great many cases. Many factors play a part in this, e.g. high blood pressure in the mother, early spastic states, biological immaturity due to youthfulness, alcoholism, smoking, etc. (J. S. Robinson, pp. 137—144).

To return to the theoretical and practical questions of birth control, from A. S. McNeilly's article (pp. 151—154) we learn how lactation influences the process of a second conception. Experience shows that during the lactation period new pregnancies are fairly rare, i.e. suckling is a "natural" contraceptive.

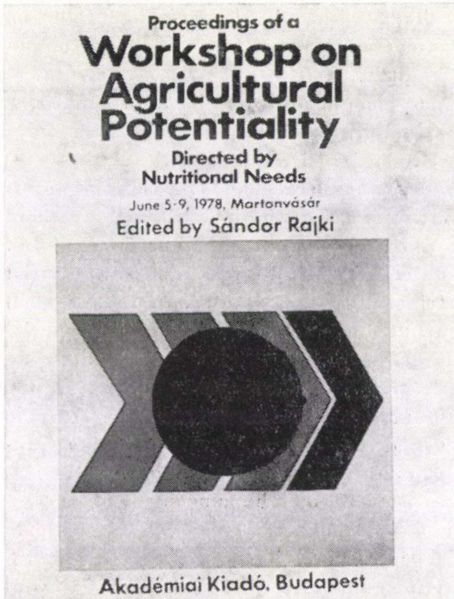
The most wide-spread current oral contraceptives exert their effects primarily by preventing ovulation. Oestrogenic factors are primarily responsible for this effect, which involves interfering with the endocrine system. In recent experiments the hormonal control of conception has been ensured without exercising any influence on the process of ovulation, thus eliminating the many unfavourable side-effects of oestrogen. Certain progestogens applied continuously at low rates provide comparatively reliable contraception. Almost all contraceptives disturb the normal functions of the endocrine and neuroendocrine systems to a greater or lesser extent, thus causing functional disorders in the female organism. Any information concerning the production and interaction of sexual hormones is therefore highly important. From this point of view the publications discussing the neuroendocrine regulating mechanisms are invaluable (G. Fink, pp. 115—160, and G. A. Lincoln, pp. 167—172).

If contraception is regarded as one of the possibilities of birth control, attention must be paid to what has happened in this field so far. According to the statistical data published by WHO the sum spent on the research and clinical testing of contraceptives all over the world was 31 million $ in 1965 and 119 million $ in 1974. The progress is remarkable even if the drop in the value of money caused by inflation is taken into consideration. This financial support was distributed between various fields. Great importance was laid on "research training", especially in the developing countries, where institutions for future investigations had to be established and research workers educated. Considerable support was given to basic research aimed at discovering new possibilities, which are indispensable for birth control. Of these, the active immunization of women against the chorion gonadotrophine is a highly promising and outstandingly important line of research. The task here is to produce an immunogenic substance which induces the formation of an autoantibody specifically against the human chorion gonadotrophine. Furthermore, new vistas are opened by the use of plant extracts exercising specific toxic effects on the young embryo. In the birth control of the future the possibility of a temporary suspension of male fertility cannot be neglected either. Certain sugar analogues, e.g. thioglucose, are capable of inhibiting spermatogenesis. The most important centres of practical birth control are the clinics, where besides testing contraceptives in practice all possible techniques of "prevention" are tried out.

All in all, it can be established that the collection of articles gives an excellent survey of the current problems of reproduction biology, not only from a medical but also from a general biological point of view. Moreover, the publications are of importance for agriculture as well, and will certainly have a fruitful effect on further investigations.

I. Benedeczky

Proceedings of a Workshop on Agricultural Potentiality Directed by Nutritional Needs. June 5–9, 1978. Martonvásár. Editor: S. Rajki. Publishing House of the Hungarian Academy of Sciences, Budapest 1979. pp. 238 (ISBN 963 05 1991 7).



This book contains the papers and discussions of a scientific workshop held at the Agricultural Research Institute in Hungary dealing with how food can be doubled in quantity and improved in quality to meet human nutritional needs by the year 2000.

The workshop was initiated by the United Nations University and jointly organized by the Hungarian Academy of Sciences and the Royal Swedish Academy of Sciences. Participants were invited from five Nordic and eight European socialist countries as well as from five specialized agencies of the United Nations.

The interdisciplinary approach to the problem is reflected by the fact that plant breeders and growers, scientists in the field of animal husbandry, nutrition and physiology, together with specialists in human nutrition and food science policy participated in the work of this meeting.

The program was divided into four sessions. Session 1 dealt with the nutritional needs of man, and Session 2 with malnutrition. These two sessions were followed by General Discussion 1 on human nutrition. Section 3 dealt with plant production and

Section 4 with animal production, followed by General Discussion 2 on agricultural potentialities.

In more detail, the book presents the following lectures:

Session 1: "Human nutritional needs — General considerations" (B. Isaksson) presents some general basic nutritional facts and emphasizes the duality of energy need *vs.* independency of need for most essential nutrients. The following paper (H. Haenel) is on "Human nutritional needs with special reference to balance between protein, carbohydrate, fat and vitamins at different levels of food supply". This paper deals with the minimal physiological human needs for protein, carbohydrate and fat. Further information is given on the amounts and recommended balances between the three main nutrients in practice, and the needs of different groups of the population with regard to this balance. At the end speculations and controversies with regard to nutrient balance and also consequences for the vitamin supply are additionally dealt with. The third paper (J. Périssé) on "The evolution of consumption patterns" was originally presented only in part at the meeting. A very interesting part of this paper discusses the relation between income and the structure of the diet in various parts of the world.

Session 2: A paper on "Malnutrition: Problems of overnourishment" (K. R. Norum) discusses its subject from an individual, a national and a global point of view. Data are demonstrated on cardiovascular diseases in conjunction with nutrition and finally problems of nutrition policy are outlined.

The following paper deals with "Problems of undernourishment with special reference to the European countries" (R. Buzina). Evidence is given for the existence of mild-to-moderate or subclinical malnutrition in European countries, especially with respect to vitamins, minerals, and trace element status. Causal factors are detailed and the need for nutrition education is emphasized, as well as the triggering effect of poor sanitation and of some infections. Thoughts on nutrition intervention programmes in European countries form a very interesting part of the paper.

Session 3: A paper entitled "Management potentials for crop improvements" deals with aspects of increase in grain and other plant production (N. V. Turbin).

A further paper is given on "Genetic potentials for improved yield" (J. MacKey), where the specific yielding ability of plant biomass is surveyed. Many aspects of the theoretical maximum for crop production are elucidated. Examples are given of the genetic yield improvement in plant breeding (grain crops, red clover) and of yield as a nutritive problem for man and animal. The author gives the plant growth for a 100 days effective vegetation period under optimal conditions as 67 tons dry matter/hectare or as 37.5 tons/hectare. Finally, plant breeding under suboptimal conditions is discussed.

The last paper in this session was presented on "Genetic potential for improved crop quality" (L. Munck). The potential for breeding for changed structure and composition in plants is discussed from many aspects. The second part of this paper gives a comprehensive survey of the possibility of adapting plants to production chains and production chains to plants.

Session 4: Questions relating primarily to protein and energy are discussed in the paper on "Criteria for optimising animal feeding" (B. O. Eggum). Data on the chemical composition of feedstuffs are presented, with special reference to the determination of soluble carbohydrate, which can yield valuable information regarding the dietary content of digestible and metabolisable energy. Factors are mentioned affecting digestibility and the efficiency of utilization of metabolisable energy.

Details are listed on feed conversion to live weight gain and energy gain in pigs, chickens and bulls. The role of environmental temperature and that of housing density is briefly dealt with. The usefulness of some indirect criteria as a measurement of blood urea and that of enzymes in blood or liver for optimizing protein utilization is then discussed and conclusions are drawn on index criteria to determine the protein status of the whole animal (and man).

The last paper of the meeting, on "Optimizing animal production towards human nutritional needs", was written by F. Fekete and T. Ferenczi.

The following areas are outlined: The consumption of and demand for animal products in various European countries with expected per capita consumption of animal products in Hungary until the year 2000. The importance of animal husbandry in agriculture as a whole, emphasizing that the rate of development of livestock husbandry in each of the European socialist countries is more rapid than that of agriculture as a whole. The positive interrelation of livestock production with a higher per capita national income is also demonstrated. A further part of the paper deals with the principles and major areas of optimization in livestock husbandry. In conclusion, the politico-economic and organizational means for an optimum increase in production are considered.

The welcoming addresses at the Opening Ceremony by J. Szentágothai, President of the Hungarian Academy of Sciences and by O. Tandberg, Foreign Secretary of the Royal Academy of Sciences, as well as those at the Closing Ceremony by M. Jul, representing the United Nations University and of F. Márta, Secretary-General of the Hungarian Academy of Sciences, are also published.

The high level of editing is demonstrated by the fact that the whole discussion for each session, as well as of the two general discussions is included in this volume, which per se forms a very useful part for the reader.

A well-compiled subject index helps the reader to find subjects of interest easily.

In conclusion, to bring together a great number of scientists from various specialized fields in human nutrition and other scientific disciplines in order to discuss their diverse problems proved an excellent idea and it has been decided that a similar meeting should follow the first one, this time in Sweden.

On the basis of the above facts, anyone concerned directly or indirectly with human nutrition problems will obtain useful and up-to-date information on the present "status of the art" from this book.

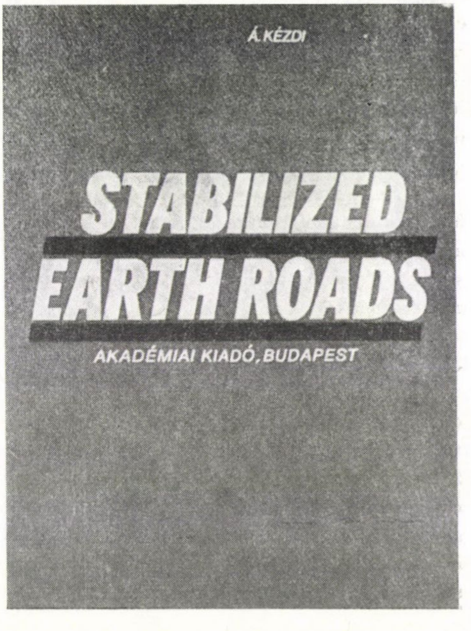
GY. PETHES

Á. KÉZDI: *Stabilized Earth Roads.* Akadémiai Kiadó, Budapest 1979.

The use of soil stabilization in developing economical road surfaces is one of the greatest inventions of recent decades, as it renders the extensive utilization of local materials possible. The introduction of the new method of construction has raised many totally new problems both in research and planning and in the field of construction. A rational solution to these problems occupies thousands of theoretical and practical experts.

The literature on soil stabilization already encompasses thousands of papers and articles, so it is almost impossible to give a full review of them. The need for a work that summarizes and evaluates the basic principles and technology on this range of subjects has been felt for a long time in the relevant literature.

Professor Kézdi's book, published in 1967,



the first comprehensive work dealing with soil stabilization in road construction in the world, served this purpose. The book — completed with new data — has now been published in English by the Akadémiai Kiadó. The new 327-pages publication contains 296 figures and 47 tables. The literary references include some 260 works.

In the preface to the Hungarian edition author observes that the preparations and experimentation concerning soil stabilization in road construction took longer than expected — more than 30 years — in Hungary and that this stage was completed some 15 years ago. His main intention is to make the reader acquainted with the physical, chemical and soil mechanical principles of soil stabilization, and to evaluate the experience gained so far. The author did not set out to write a book of ready-made recipes or to give strict instructions for design and construction. Nevertheless, the material in the book could greatly facilitate the elaboration of such specifications.

With this book Prof. Kézdi also wished to complete the research started in 1948 by Prof. Dr. Jáky with the support of the Hungarian Academy of Sciences and which he himself directed from 1950 onwards. He is convinced that the conditions necessary for mass construction have existed in Hungary since the middle of the sixties; the general introduction of the method in agriculture only requires cooperation, organization and guidance.

It should be mentioned here that in the last two decades the bases of many highways and agricultural roads have been made by means of soil stabilization, with relatively modern equipment.

The highly complex subject discussed in the book is divided into 9 chapters.

In the introduction the importance of constructing stabilized roads is discussed and the prospective savings which could be made by establishing a network of agricultural roads are assessed. Then a brief survey is given of the development of soil stabilization in Hungary and abroad, as well as of the methods of constructing stabilized roads. Finally, 20 foreign and Hungarian works discussing at length the questions of stabilization are mentioned.

The second chapter deals with the physical and chemical aspects of soil stabilization. When discussing the basic principles of soil physics the author describes an illustrative method elaborated by him for characterizing the soil condition by the volume percentage of solid particles, water and air; this method may be of help in following changes in the soil condition and clearly representing certain properties of the soil. A summary of the soil classification systems is followed by the description of methods for testing stabilized soil samples. The discussion of interaction between the soil components is of a particularly high standard and is theoretically very thorough.

The third chapter gives detailed information on mechanical stabilization. It deals with the porosity conditions of granular systems, the characteristics of various soil mixtures, and questions connected with mixing; the general problems of compacting are also discussed in this chapter. In regions rich in coarse-grained materials mechanical stabilization in constructing agricultural and forest roads is of particularly great importance, since it can easily be carried out without any special equipment.

The longest chapter, 60 pages in length, is the fourth chapter, which deals with the cement stabilization of soils. First the interaction between cement and soil is discussed, then the properties of cement-treated soils are presented. In the second half of the chapter, which treats theoretical and practical problems at length, a detailed analysis is given of the effects of construction operations and aggregates on the properties of soil-cement, and finally questions connected with the design and testing of cement-soil mixtures are dealt with.

Soil stabilization with lime is the subject of the fifth chapter. First the physical and chemical action mechanisms of lime and the effect of liming on the physical characteristics of the soil are described. After investigating the effects of various aggregates the chapter discusses the aspects of designing soil-lime mixtures, briefly touching upon the possibility of adding fly ash.

Here it should be mentioned that since 1967 considerable progress has been made in the field of constructing bases bound with fly ash and lime, both in Hungary and abroad. These new methods will help in the more rapid construction of agricultural and forest roads.

Stabilization with bitumen and tar is the title of the sixth chapter, which first discusses cut-back bitumen types, then the physico-chemical and mechanical aspects of stabilization, also presenting in detail the theory developed by the author for the examination of the rheological properties of bitumen-stabilized soils. This is followed by an examination of the effects of aggregates and of points which must be considered in designing bituminous mixtures. The chapter is completed by an account of experiments on the stabilization of sand with tar and trass carried out in the laboratory of the Geotechnical Department of the Technical University, Budapest, under the guidance of the author. It should be pointed out that cation-active bitumen emulsions which set slowly and which have been widely used for some years are suitable in agriculture as well, mainly for stabilizing fine sands.

The seventh chapter deals with chemical stabilization. After presenting the stabilization methods it considers in detail the possibilities of stabilizing with chlorides and phosphoric acid, then reports and evaluates some results obtained by the use of natural and artificial polymers (resins, calcium acrylate, aniline furfurol, sulphite solution) and other synthetic resins.

The new edition of the book gives a brief survey of the experience gained in Hungary and abroad in treating soils with RRP (Reynolds Road Packer) chemicals which have been widely used in recent years. Owing to its simple technology and economic efficiency, chemical soil treatment is of great importance in the home-made construction of agricultural roads in regions poor in granular materials.

The eighth chapter of the book discusses questions related with designing stabilized earth roads. To begin with, agricultural and forest roads are considered with a view to the construction of stabilized roads; then the effects of the climatic factors which have to be taken into account in the course of design are evaluated. After this the technical characteristics of stabilized earth roads are described, and information is given on how to plan the thickness of the road surface. The author describes several methods, including one he elaborated himself for checking the strength of rigid soil-cement used as a road surface on the basis of the stress conditions in the two-layer system.

The last chapter discusses the construction problems met when making stabilized earth roads. After an evaluation of the advantages and disadvantages of different methods (mixing in place, transportable and stationary mixing plants) some experimental and theoretical questions of soil mixing and compaction are considered. A description is then given of simple and complex machines of foreign or Hungarian manufacture, and of the work phases necessary in constructing stabilized earth roads when they are mixed in place.

Even this brief survey of the contents of the chapters is sufficient to show that the highly complex material dealt with in the book is rationally compiled and well arranged, and that the problems arising in the field of theory and practice are discussed with great competence. The course of the discussion, as well as the weighing and critical evaluation of the material, are excellent and make the book suitable for use not only at universities and research institutes, but also by design and construction engineers, particularly by those engaged in road construction.

In accordance with the aim of the book, Prof. Kézdi clearly demonstrates the economic importance of constructing stabilized earth roads. He emphasizes that constructing stabilized earth roads is a necessary precondition of any further progress in agriculture and forestry, especially considering the fact that at the time when harvesting is carried out in agriculture and wood transportation in forestry, so that good roads are badly needed, a large proportion of the earth roads are unusable. The book will also be exceedingly useful for agriculturists and foresters.

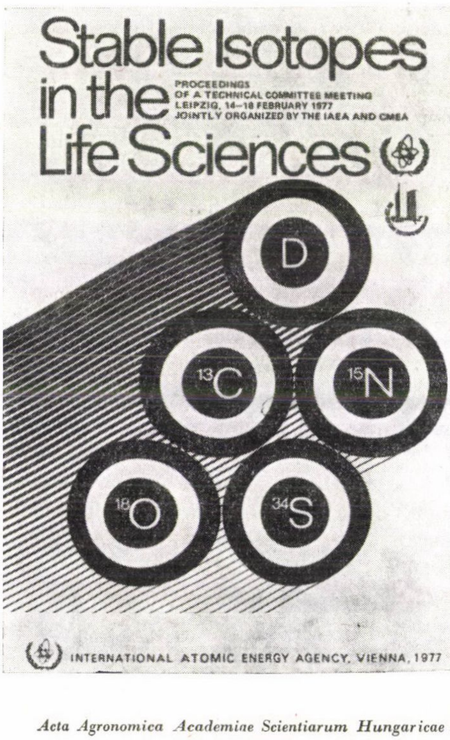
Attention should be called to the great pedagogical sense shown by the author in writing the book: he always leads the reader through simpler cases to the most complex questions with clear and convincing reasoning.

The text is illustrated with examples taken from practice and by carefully designed and highly instructive figures.

To sum up, it can safely be stated that Prof. Kézdi's work is perfectly suited to its purpose; the clear, high standard of discussion will win it a prominent place in the literature. The previous editions were also favourably accepted by professional circles all over the world.

L. GÁSPÁR

Stable Isotopes in the Life Sciences. Panel Proceedings Series. Proceedings of a technical committee meeting on modern trends in the biological applications of stable isotopes jointly organized by the International Atomic Energy Agency and the Council for Mutual Economic Assistance and held in Leipzig, 14—18 February 1977. International Atomic Energy Agency, Vienna 1977. STI/PUB/442.



Separation of stable isotopes (Sessions 1 and 2). Bakhtadze, A. B.: Review: Separation of stable isotopes. The technical separation of ^{13}C is carried out in the form of hydrogen cyanide, hydrocarbonate and carboxy group in nine-metre long columns in the Soviet Union. The annual production amounts to 1.2—1.5 kg and the product is concentrated to 99%. Stable nitrogen is concentrated in the form of nitric acid, and the ^{15}N reaches 99 at.%, with a production level of 10 kg a year. The separation of ^{18}O starts from heavy water and proceeds *via* transformation into nitrogen oxide; the annual output is 5.5 kg of 98.5 at.% product. The concentration of ^{34}S is carried out in the form of sulphurous acid, and at the end of the third column 0.5 kg/year of 90 at.% stable sulphur is obtained. Daniels, W. R.—Edmunds, A. O.—Lockhart, I. M.: Some aspects of the separation and use of the stable isotopes of carbon, nitrogen and oxygen. ^{13}C is separated by the cryogenic distillation of carbon monoxide at 98 at.%. For the purposes of reductive amination stable nitrogen is produced in the form of ammonia-^{15}N in the PROCHEM Laboratories, and labelled amino acids are marketed. ^{18}O and ^{34}S stable isotopes are produced in highly concentrated forms, together with doubly ($^{13}C_2H_4$) and triply labelled ($^{13}C^{18}O^{34}S$) compounds, the latter mainly for studying environmental protection problems. The mass numbers of the atoms in the compounds are detected by nuclear magnetic resonance spectra, or are measured by mass spectrometry. Oziashvili, E. D.—Egizarov, A. S.—Dzidzheishvili, S. I.—Bashkatova, N. F.: Separation of carbon isotopes by chemical isotopic exchange in the CO_2-amine carbamate system. Owing to the high at.% isotopic exchange a considerable proportion of stable carbon is exchanged between carbon dioxide and molecular organic compounds. So with columns 1000 mm long and 25 mm in diameter the maximum separation factor (1.94) is obtained for a carbon dioxide — normal dibutyl amine octane.CO_2 system, and this is suitable for special labelling. Văsaru, G.—Gheţe, P.—Covaci, I.—Atanasiu, M.: Separation of carbon-13 by thermal diffusion. In the concentric thermal diffusion tube continuous separation is carried out, with methane as the progress gas; this produces a 20 at.% concentration of $^{13}CH_4$. Ertel, G.—Ewald, G.: Cooperation among Comecon member countries in the production and use of stable isotopes and of compounds labelled with them. Scientific and technical cooperation is being established between the participating countries in the production of stable isotopes, the elaboration of techniques for labelling with stable isotopes and the instrumentation required for their application. Krell, E.—Jonas, C.: Industrial plants for production of highly enriched nitrogen-15. Chemical exchange is carried out in a $NO/NO_2/HNO_3$ system at 25 °C, and the ^{15}NO end-product is separated in the liquid state at —151 °C. In an automatically operating, two-section cascade the ^{15}N isotope can more than 250 different ^{15}N-labelled compounds are produced on an industrial scale and marketed. Abzianidze, T. G.—Andryushchenko, V. I.—Bakhtadze, A. B.—Egiazarov, A. S.—Tkeshelashvili, G. I.: Distribution of nitrogen and carbon isotopes in a gas discharge. Isotopic effects were studied with compounds containing nitrogen, oxygen and carbon in a gas discharge at room temperature and at the temperature of liquid nitrogen, —195.8 °C. Asatiani, P. Ya.—Giorgadze, L. P.—Partsakhashvili, G. L.—Tevzadze, G. A.—Chikaidze, I. V.: Industrial pilot plant for the production of oxygen-18. At present 7.2 g/day stable oxygen with ^{18}O at a concentration of 90—95 at.% is obtained by low temperature rectification of nitric oxide on a laboratory scale. Staschewski, D.: Production of oxygen-18 and oxygen-17 by countercurrent distillation of reactor-grade heavy water. Electrolysis and the subsequent distillation of heavy water is the only source for the extraction of heavy oxygen isotopes. In this way oxygen-18 can be obtained in an absolutely pure form (99.99 at.%). In the course of distillation the intermediate product is concentrated in $H_2{}^{17}O$, as the oxygen-17 is converted electrolytically directly to water. The idea of oxygen isotope separation and concentration which was raised in 1966 has since been elaborated on a technological scale in Karlsruhe and is now applied all over the world. Ambartsumyan, R. V.—Bekov, G. I.—Gorokhov, Yu. A.—Letokhov, V. S.—Makarov, G. N.—Mishin, V. I.—Ryabov, E. A.—Puretsky, A. A.—Chekalin, N. V.: Laser separation of isotopes. The selective action of an infrared laser field on the vibration-rotation transition of some polyatomic molecules (SF_6, $CH_3{}^{15}NO_2$, CCl_4), and the selective ionization of the ^{40}K atom by laser radiation were studied for use in isotope separation.

Synthesis of labelled molecules (Session 3, Part 1). Crespi, H. L.: Review. Biosynthesis with deuterated micro-organisms. Cell and tissue cultures of micro-organisms and higher plant and animal organisms can be grown without toxic damage in 99.7 at.% D_2O, while higher plan s tolerated only 60 at.%, and animal organisms only 40 at.% without damage. Deuterated plant pigments, proteins, ribonucleic acids and lipids were analysed by magnetic resonance spectroscopy, infrared spectroscopy, Raman spectroscopy and neutron scattering. By the technique of isotopic hybridization of deuterated proteins analytical data were obtained on 1. the amide protons of peptide bonds, 2. the protons of selected amino acids, and 3. the protons of prostetic groups. Oziashvili, E. D.—Kobaladze, M. G.—Kakuliya, D. A.—Beridze, Eh. A.: Production of water labelled with oxygen isotopes by the reduction of nitric oxide. The reduction of nitric oxide by hydrogen in the presence of various catalysts (iron, cobalt, nickel, platinum) at 750—800 °C was studied. During the reduction the concentration of ^{18}O fell from 99.99 at.% to 95%. Banerji, A.: Application of carbon-13 in the biosynthesis of fusicoccin. Various processes in the biosynthesis of fusicoccin were studied using the precursors (1-^{13}C) and

(2-^{13}C)-acetate and (3-^{13}C) mevalonic acid. The stable carbon-13 isotope was determined by the nuclear magnetic resonance method (NMR).

Analysis (Session 3, Part 2; Session 4). Wetzel, K.: Review. Analysis of stable isotopes. The minimum error for results obtained by measuring stable isotopes with mass spectrometry, emission spectrometry, gas chromatography and chemical analysis is 10^{-6} g, while the relative error for the determinations is 0.1%, primarily in the case of ^{15}N analyses. Letokhov, V. S.—Ryabov, E. A.—Tumanov, O. A.—Gomanyuk, A. S.—Zharov, V. P.: High-sensitivity method for the absorption measurement of the relative concentration of isotopes. To determine low concentrations of ^{12}C, ^{13}C, ^{16}O, ^{18}O, ^{14}N and ^{15}N CO_2 and N_2O lasers were applied to various molecules, and the optical and acoustic signals from two spectrophones were compared periodically. Ordzhonikidze, K. G.—Kerner, M. N.—Birkaya, L. L.: Investigation of the dissociation and ionization of NO, N_2O and NO_2 in the ion source of a mass spectrometer. The degree of dissociation and recombination was studied in the ionization potential range 45—100 V on the basis of molecular ionization. Pheiffer Madsen, P.: Analysis of gaseous nitrogen-15 by emission spectrometry in nitrate reduction experiments in soil. Nitrogen-15 was used as a tracer in nitrate reduction experiments. In a large number of samples the small quantities were determined with a special technique, and the ratio of ^{14}N and ^{15}N isotopes was measured by emission spectrometry. Faust, H.—Reinhardt, R.: Sample preparation methods for automatized emission spectrometric analysis of nitrogen-15 in biological compounds. Data obtained by isolating ammonium nitrogen from human serum protein amide and soluble amide and by determining the stable nitrogen give information on the extent of amino acid transformation into carbamide. Nitrogen isolation by alkaline hydrolysis of protein amido nitrogen has been raised to a routine level, as has the reaction of 26 amino acids with sodium hypobromite, and a method elaborated for the immediate determination of nitrogen metabolism by continuous measurement of ^{14}N and ^{15}N ratios in the released molecular nitrogen gas. Beer, K.—Lippold, H.—Ackermann, W.: Emission-spectrometric determination of nitrogen-15 in trace amounts of N_2, NO and N_2O after gas-chromatographic separation: a new, combined method for investigating denitrification in soil. Helium or neon was employed as filler gas, and a combination of gas chromatography and emission spectrometry was used for the isotopic analysis of gases. With a view to evaluating the interaction between nitrogen fertilizers and soils a sensitive technique for measuring small quantities of molecular nitrogen has been developed which has a maximum error of $\pm 3\%$. Bengsch, E.—Ptak, M.: Analyse des spectres de résonance magnétique nucléaire du carbone-13 pour quelques acides aminés enrichis et les peptides correspondants (Analysis of carbon-13-NMR spectra of some enriched amino acids and related peptides). In studying the chemical properties and configurations of peptides and proteins amino acids concentrated with 80 at.% ^{13}C, or less frequently with ^{15}N and D_2O, provide readily evaluated data. Botter, F.—Darras, R.—Engelmann, C.—Scaringella, M.—Basset, G.—Moreau, F.—Marsac, J.: Analyses isotopiques de l'hydrogène et l'oxygène par spectrométrie infrarouge et par activation (Isotopic analyses of hydrogen and oxygen by infra-red spectrometry and activation — Applications to biological media). Two methods are described for the activation of blood samples for isotopic analysis to determine the ^{18}O content. The heavy water (D_2O) content of circulating blood, which is of diagnostic importance in clinical practice, is determined by infrared spectrometry. Vorsatz, B.: Détermination des isotopes stables à l'aide de l'analyse par activation avec des neutrons de 14 MeV (Determination of stable isotopes using 14 MeV neutron activation analysis). By means of a neutron generator stable isotopes of many elements (N, O, Mg, Si, S, Cl, K, Fe, Cu) can be produced by means of nuclear reaction (nγ) and quantitatively determined by gamma spectrometry. This method has special importance in the direct analytical evaluation of metallic isotope occurrence. Holmes, A.—Emerson, P. M.—Drysdale, H. C.: Use of chromium-50 as a label for red blood cells in studies with pregnant women and premature infants. The stable isotope chromium-50 is adsorbed onto the donor blood *in vitro* and then infused into the circulatory system of the examined organism. After the exposition period chromium-51 is formed by neutron activation and this can be precisely determined by gamma spectrometry. Isotopes are also formed after neutron activation from other elements (e.g. iron-59, zinc-65, rubidium-86, phosphorus-32), the direct measurement of which also provides sensitive data. The method is used in clinical diagnosis to study haemolytic anaemia, cerebral haemorrhage, developing embryos, etc. Middelboe, V.: Determination of trace amounts of total nitrogen by isotope dilution. An unknown quantity of test nitrogen (^{14}N) is mixed with a known quantity of standard nitrogen (^{15}N), and the isotope composition is determined on the basis of the optical emission spectrum. The method is suitable for the routine determination of a total nitrogen content of 500 nanogrammes and for the determination of a one ppm level in 1 ml water with a relative error of 5—10%.

Application in biochemistry and pharmacology (Session 5). Matwiyoff, N. A.—Walker, T. E.: Review. Trends in the use of stable isotopes in biochemistry and pharmacology. The use of ^{13}C, ^{15}N and ^{18}O in the life sciences and the employment of nuclear magnetic resonance spectroscopy and mass spectrometry as analytical techniques have opened up new aspects in studies on the metabolism of drugs and in the determination of the influence of drugs on the metabolic processes. Hübner, G.—Hischberg, K.: Demonstration of *de novo* synthesis of enzymes by density labelling with stable isotopes. The hormonal regulation of enzymes and inductions related to development were studied in plant cells by *in vivo* density labelling of proteins with $H_2{}^{18}O$ and ^2H_2O. The *de novo* synthesis of cytokinin-induced nitrate reductase and gibberellic acid-induced phosphatase has thus been directly proved through the increase in activity. Wahren, M.—Bayerl, B.—Lorenz, B.—Möbius, G.—Rummel, S.—Schmidt, K.: Experiments with nitrogen-15 in the first stages of non-enzymatic dinitrogen fixation. In the process of nitrogen fixation catalysed ammonia or its derivatives. Through a non-enzymatic reaction of the transition metal complexes of dinitrogen (Mo, Fe), with the split molecular nitrogen and the uptake of six electrons and six hydrogen atoms diimine or hydrazine are formed in the further stages. Gerster, R. — Dimon, B. — Tournier, P. — Peybernes, A.: Etude au moyen d'oxygène-18 de la photorespiration: photoconsumation et incorporation d'oxygène dans le glycolate, la glycine et la sérine (Oxygen-18 as a tool for studying photorespiration: oxygen uptake and incorporation into glycolate, glycine and serine). The intensity of photosynthesis and photorespiration in algae and leaves has been determined by measuring the evolution of $^{16}O_2$ and the uptake of $^{18}O_2$. According to the experimental results a considerable amount of $^{18}O_2$ is incorporated into the glycolate, glycine and serine compounds of photorespiring algae. Incorporation is inhibited to 20—35% by 10^{-3} M cyanide. $^{18}O_2$ shows an intensive accumulation in the carboxyl group of glycine and serine. Winkler, E.—Hübner, G.: Concepts for the interpretation of tracer experiments and their application in the investigation of nitrogen metabolism. A model for investigating the protein metabolism is outlined on the basis of various degrees of ^{15}N accumulation in the organs of broad bean (Vicia faba).

Applications in biology and medicine (Session 6, Part 1). Klein, P. D.—Szczepanik, P. A.—Hachey, D. L.—Schoeller, D. A.: The Argonne Bioanalytical Center: A resource for collaborative biomedical applications of stable isotopes. Many drugs, metabolites and bioactive compounds have been labelled with stable isotopes (^2H, ^{13}C, ^{15}N), and the compounds have been applied in clinical research and practice; after separation the isotope ratios are determined by a combination of gas chromatography and mass spectrometry. The team have given an account of the results of pharmacological, pediatrical, gynecological and gastroenterological applications at a number of conferences (1971, 1973, 1975) and have published more than 160 papers on the above subjects. Review: Garlick, P. J.—Waterlow, J. C.: Measurements of protein turnover in man with nitrogen-15. According to protein metabolism studies made on the basis of glycine-^{15}N labelling the amount of carbamide formed from intravenous and oral doses of amino acid is primarily influenced by food intake, nutritional status and age. Hartig, W.—Faust, H.—Czarnetzki, H. D.—Winkler, E.: Studies with nitrogen-15-labelled amino acids for a quantitative description of nitrogen metabolism in man. Healthy and traumatic (stressed) patients were compared for nitrogen metabolism: 1. The decomposition of protein is always increased under stress conditions. 2. Amino acids are incorporated under stress conditions, but to a substantially lower extent than in healthy organisms. 3. Carbamide synthesis and secretion increase during stress. 4. In healthy humans 23% of glycine-^{15}N is excreted in 24 hours, while immediately after cholincysectomy this figure is 41%. 5. Absorption from the intestines is much more intensive in healthy than in stressed persons.

Applications in agriculture (Session 6, Part 2; Session 7). Review: Koren'kov, D. A.—Faust, H.: Application of stable isotopes in agriculture. Investigations with stable nitrogen have revealed that 20—30% of nitrogen fertilizers becomes fixed in the soil. Nitrogen fixed in fulvic acids and in as yet unidentified compounds is much more readily taken up by plants than the free form of nitrogen. The efficiency of special nitrification inhibitors can be successfully measured by stable nitrogen labelling. Havassy, I.—Boda, K.—Kosta, K.—Várady, J.—Rybosova, E.: Utilization of nitrogen-15 urea for protein synthesis in domestic fowl. A quantity of 47 mg/day 2—4% urea-^{15}N was administered to fowl perorally for 10 days. Seven days after the last peroral dose stable nitrogen was incorporated to the extent of 0.047 at.% in the TCA-precipitable protein fraction of muscle tissue. At the same time, in the amide nitrogen of plasma proteins stable nitrogen accumulated to the extent of 0.302 at.%. The above data show that urea nitrogen is only utilized to a slight extent by domestic fowl. Henning, A.—Gruhn, K.—Jahreis, G.: Incorporation of nitrogen-15 from lysine and wheat in the eggs and bodies of laying hens. In the eggs and carcass 48% of the applied stable nitrogen accumulated from the labelled wheat and 78% from the lysine. With the lysine test the concentration of ^{15}N could be demonstrated in all amino acids in the egg-white and egg-yolk, but to the highest extent in the non-essential amino acids. Iglewski, S. M.—Szarvas, T.—Pozsár, B. I.: Stimulation effects of synthetic cytokinins on the uptake and incorporation of nitrogen-15-labelled ammonium nitrate and urea in wheat leaves. A larger proportion of urea nitrogen is accumulated in the TCA-insoluble fraction thad of stable nitrogen originating from inorganic nitrogen fertilizer. Ammonium nitrogen shows 76% conversion and nitrate nitrogen only 60% conversion compared to the incorporation of urea nitrogen. Under the influence of synthetic cytokinin (benzyladenine) a 23—29% higher incorporation of nitrogen from both fertilizers could be demonstrated in leaf proteins. Gebhart, G.—Tereza Zebrowska—Souffrant, W.—Rosemarie Köhler: Determination of nitrogen absorption and endogenous nitrogen secretion in the digestive tract of pigs fed with nitrogen-15-labelled dried whey. Pigs fistulated in two places and weighing between 15 kg and 54 kg were fed on ^{15}N-labelled dried whey. Samples of the digesta were taken from the duodenum and the terminal ileum. The absorption of nitrogen was 17% in the duodenum and 90% in the terminal part of the small intestine. The true digestibility calculated from the amount of ^{15}N in the food and the faeces was 98%. Králová, M.—Draždák, K.—Stránský, P.—Kubát, J.: Determination and isotope-ratio analysis of different forms of nitrogen in soils. According to the results of investigations, labelled ammonia-^{15}N is rapidly transformed into molecular nitrogen in soils as a consequence of the denitrifying activity of the soil. The ammonium, nitrate and nitrite contents were determined by classic methods and by mass spectrometry with the aid of labelling with stable nitrogen, in the case of very low nitrogen levels.

Appendix. The last chapter of the book gives a summarised report in English and Russian on modern metabolism studies based on stable isotope labelling and spectrometric measurements. Finally, a list of the chairmen and secretaries of the sessions and a list of participants are presented. Abbreviations of the measuring units relevant to the subject are given in tabular form.

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Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 30 (3—4), pp. 285—287 (1981)

GÉZA LÁNG
1916—1980

The death of Prof. Géza Láng, regular member of the Hungarian Academy of Sciences, head of department at the Plant Production Institute of the Keszthely University of Agricultural Sciences, is a grievous loss for the scientific life of Hungary.

He was not only an industrious worker but also a leading spirit of science, with a mind which not only collected and analysed but also synthesized. He paid thorough attention to details, but was able to comprehend the entire scope of plant production. His scientific career progressed steadily, advancing along the objective, logical line of his subject in accordance with the requirements of agricultural production in Hungary, and he was not diverted by fashionable ideas.

As regards his scientific public activity, he played an active part in debates on plant production, and contributed fruitful ideas to the questions of soil cultivation, nutrition, etc. He did not become enthusiastic about new ideas simply because they were new, but nor did he raise objections to rational, well-considered progress.

His personality was a fine alloy of the true man, the broad-minded highly educated thinker, the prominent researcher and the hard-working participant in scientific public life. He was a scientist who wisely accepted reality, but remained faithful to the principles of his vocation and never lost sight of the universal interests of agriculture.

The two main characteristics of Láng's personality, the experimenting researcher and the synthesizing scientist, combined harmoniously, the experimenting researcher being of assistance to the comprehensive mind of the scientist.

His unrehearsed summaries of the debates he led as president of the Plant Production Committee of the Hungarian Academy of Sciences, which went straight to the point, always aroused admiration.

His main line of research was aimed at increasing the fertility of the soil. It was on this subject that his first papers were written. He dealt with the effect of phosphorus fertilizers, the fermentation of manure, the theory of including grass in crop rotation and the guiding principles of soil conservation. As he wrote in his autobiography, at the beginning of his career meadow and pasture management was his main interest, while later his attention turned towards investigations aimed at increasing soil fertility. He carried out experiments for years to elaborate a system of manure management adapted to Hungarian conditions. This work was summed up in an academic doctor's dissertation in 1954, entitled "Directives for soil conservation in the present situation of Hungarian agriculture". The principles laid down in his study "Deep cultivation of soil" (1964), which comprised the essence of long years of debate, are still valid today.

From the middle of the sixties Láng concentrated on the subject of fertilization. He organized and directed a uniform national experimental network for fertilization. He published papers on the fertilizer responses of crops in various soil types. He searched for and analysed correlations which could be generalized. His inaugural lecture at the Academy (1971) dealt with the plant production problems of intensive fertilization. At the VIII International Congress on Fertilization he presented a paper entitled "Theoretical bases of plant nutrition and the international practice of using organic and inorganic fertilizers".

Besides general questions of plant production, such as nutrition, soil cultivation and crop rotation, Láng was deeply interested in problems involved in the cultivation of Hungary's major crops: wheat, maize, sugar-beet, potatoes and fodder plants. It is amazing that he managed to be familiar with and actively involved in such a wide range of agricultural fields.

His experiences in plant production are summed up in a book entitled "Plant Production" (1952), which was used by several generations as a textbook. In 1976 he published a book entitled "Crop Production", in which the rudiments of large-scale crop production are presented for university students. It was on his initiative and under his editorship that the 1215-page "Handbook on Plant Production" was published in 1966, in which 42 co-authors summarized all that should be known about plant production in Hungary.

We have lost an excellent researcher and an enthusiastic teacher who was devoted to his pupils and kept their minds constantly on the move, thus increasing their sensitivity to the problems.

With his death the ranks of those who have a grasp of the science of plant production as a whole, but are nevertheless able to penetrate into the details, have once again been thinned.

B. GYŐRFFY

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 30 (3—4), pp. 289—295 (1981)

EFFECT OF CEMENT-KILN DUST ON THE MAIZE PLANT

By

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Studying the effect of cement-kiln dust on the maize plant it was found that in consequence of the continuous pollution the leaves became evenly covered with cement. As a result the height of the plant decreased. The initial small degree of pollution had a positive effect on the growth rate of the leaf blade, but the development of the cement crust had a negative effect. The dust layer stuck to the leaves and blocked the stomata in the form of cement plugs, thus causing disturbances in the carbon assimilation and in the heat and water regimes of the plant. The intensity of respiration and the catalase enzyme activity in leaves polluted for a long time decreased. A small amount of pollution did not affect the total pigment content of the leaves, but a larger extent of pollution increased it significantly. Fertilization was adversely affected by cement-kiln dust. While a lower degree of cement pollution did not reduce the dry weight, it significantly decreased the ear production.

Introduction

The most dangerous dusts of industrial origin are those which not only form a crust, but also enter into a chemical reaction with the water content of the air and are thus chemically active, such as gasogene powder, potassium silicate powder, powdered lime and cement dust (CZAJA 1962).

The alkaline solution formed from the cement dust settling on the leaf surface penetrates into the assimilating tissues through the epidermis cells or stomata and causes damage by causing the denaturation of the nucleus and the chloroplasts. A further problem is that "cement plugs" block the stomata, causing serious disturbances in the carbon assimilation and in the water and heat regimes of the plant. The Dunai Cement és Mészművek (Danube Cement and Lime Works) pollutes the environment with 103.6 ton/km^2 cement dust a month according to the data of BIRÓ (1976).

The current investigations were aimed at finding out how the cement-kiln dust of the Danube Cement and Lime Works (DCM) influences the growth, development, major metabolic processes and yield of the most important field crops. The results may make it possible to calculate numerically the possible yield reductions in plant species grown in districts with different emission loads, and also give advice on how to choose species tolerant to cement-kiln dust.

Material and method

On the experimental grounds of the Keszthely University of Agricultural Sciences MVSC-580 hybrid maize was sown as indicator plant in alternating rows with 30×70 cm spacing. This is a medium late, drought tolerant variety with good productivity. Sowing was carried out on 26th April and harvesting on 18th October 1978. The viscosity index of the soil (after Arany) was 36—37, the pH value (KCl) 6.5—7.5 and the total humus content 1.7%. The experiment was set up in four replications, and of the 60 plants sown in each three-row plot 10 plants from the middle row were evaluated. The data in the tables always show the average of 4 replications.

When artificially polluting the plants the emission load of the DCM was taken for the basis. The methods presented in the literature were applied so as to attain the same amount of pollution on the maize plants included in the experiment as on those grown in the neighbourhood of the cement works. This was achieved with continuous pollution carried out by utilizing micrographs taken at the site (STEUBING—KLEE 1970, STEUBING—KUNZE 1972, STIEBER 1973) and measuring the difference in weight and thickness between clean and polluted leaves (KLINCSEK 1975).

The levels of artificial pollution were about 15 and 30 g/m^2 a month. The values represent the pollution levels of areas at a distance of 5—6 and 2—3 km, respectively, south-east of the source of emission. [Some authors indicate much higher values, e.g. PAJENKAMP (1961) uses a figure of 1.5 g/m^2 a day and BOHNE (1963) 3.8 g/m^2 a day.]

To collect cement dust for the purpose of artificial pollution a 20×20 m plastic bag furnished with 50 cm high walls was placed under the dust torch at a distance of 700 m from the DCM. Artificial pollution was started at the 2-leaf stage and continued until the end of vegetation by producing a mist of very fine distribution every third days in the early morning or in the evening hours prior to carrying out pollution.

From the time the male and female flowers appeared until the end of the flowering period the treatments were applied every day, and always at the time of flowering (between 6 and 10 a.m.), so that any damage caused by the cement dust to the pollen or pistil could be observed. Care was taken to ensure that the flowers received approximately the same amount of cement dust as the flowers in the DCM districts with 15 and 30 g/m^2/month loads did. (This was made possible by making observations and taking measurements and micrographs in the field.)

The plant height and leaf area were continuously measured during the vegetative period (HUSSIEN 1968).

Of the physiological processes the catalase enzyme activity was determined by Frenyó's method (FRENYÓ 1973), the intensity of respiration with a Warburg manometer (KOVÁCH 1958), the total pigment content by spectrophotometry (BRUISMA 1963), the opening of the stomata with a porometer (KANEMASU 1969) and the soluble protein content with the "Folin" method (FLETCHER—OSBORNE 1966).

Results

Cement-kiln dust pollution had no effect on the height of plants in the first third of the vegetation period. Later, as a result of continuous pollution, the first leaves became coated with a cement crust of increasing thickness. A particularly thick cement layer settled around the leaf-sheaths. In consequence, the plant height measured from the 74th day showed a decrease significant at the 0.1% level compared to the control (Table 1).

Under the influence of a low degree of pollution the first leaves were initially (until the age of 64 days) larger than those of the untreated plants, but the further settling of cement dust, or a higher degree of cement dust pollution had an adverse effect on the growth rate of the leaf-blade (Table 2). MALY (1976) obtained similar results. The dust layer which stuck to the leaves,

Table 1

Effect of cement-kiln dust on the intensity of growth in maize

Age of plant, day	Height, cm			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	Height, cm
30	24.51	24.50	24.60	untreated	115.43
40	42.41	42.44	41.46		
50	58.40	58.22	58.14	15 g/m²/month	111.04
64	81.60	81.36	81.36		
74	119.11	120.41	114.17	30 g/m²/month	104.31
86	140.82	137.17	130.33		
96	158.45	149.89	140.24		
116	171.25	161.13	148.09	$LSD_{5\%}$	0.15
126	176.33	164.99	151.33		
136	181.39	170.24	153.39		

Calculated value of $LSD_{5\%}$ between the treatments as a function of time: 0.59.

Table 2

Effect of cement-kiln dust on the leaf area of maize

Age of plant, day	Leaf area, dm²/plant			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	Area, dm²/plant
30	27.36	28.27	26.49	untreated	40.91
64	46.22	40.39	39.13	15 g/m²/month	36.68
116	49.15	41.39	39.34	30 g/m²/month	34.99
				$LSD_{5\%}$	0.18

Calculated value of $LSD_{5\%}$ between the treatments as a function of time: 0.24.

Table 3

Effect of cement-kiln dust on stoma opening in maize leaves

Age of plant, day between 11 a.m. and 1 p.m.)	Resistance to diffusion, Ohm sec cm⁻¹			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	Resistance to diffusion sec cm⁻¹
30	27.65	23.21	21.16	untreated	28.54
64	28.72	21.78	19.03	15 g/m²/month	21.72
116	29.26	20.32	16.80	30 g/m²/month	19.00
				$LSD_{5\%}$	0.46

Calculated value of $LSD_{5\%}$ between the treatments as a function of time: 0.42.

especially on the upper surface, blocked a considerable proportion of the stomata in the form of cement plugs, thus causing serious disturbances in the assimilation and in the water and heat regimes of the plant, particularly in the midday hours (Table 3).

The temperature of the leaves on polluted plants was in some cases 12—15 °C higher than that of control plants with the same exposure. The closing of the stomata not only prevented the inward diffusion of the necessary amount of carbon dioxide but, because of the higher temperature caused by reduced transpiration, inhibited the phosphorylation of sugars and thereby the removal of starch from the site of origin. Other authors have concluded that the light absorption of the dust layer, the lower intensity of transpiration and the overheating of leaf tissues are not among the critical factors (LERMAN 1972, DARLEY 1966, BALKS 1953). Cement pollution had an unfavourable influence on other physiological processes of the plant as well.

In the first third of the vegetative period the catalase enzyme activity did not show any difference due to pollution compared to the control plants. Later, however, the rate slowed down, especially in the first leaves, which had

Table 4

Effect of cement-kiln dust on the catalase enzyme activity of maize leaves

Age of plant, day	O_2 load of 10 leaf discs of 5 mm diameter, ml/2 minutes			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	O_2 ml/2 minutes
30	0.25	0.22	0.18	untreated	0.26
64	0.24	0.22	0.18	15 g/m²/month	0.20
116	0.29	0.19	0.14	30 g/m²/month	0.16
				LSD5%	0.01

Calculated value of LSD5% between the treatments as a function of time: 0.01.

Table 5

Effect of cement dust pollution on respiration in maize leaves

Age of plant, day	O_2 consumption, ml/g dry matter/hour			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	O_2 consumption ml/g
30	2.679	2.116	1.687	untreated	2.811
64	2.902	2.441	1.918	15 g/m²/month	2.336
116	2.853	2.453	1.970	30 g/m²/month	1.859
				LSD5%	2.0

Calculated value of LSD5% between the treatments as a function of time: 1.28.

Table 6

Effect of cement-kiln dust on total pigment content in maize leaves, mg/g fresh weight

Age of plant, day	Total pigment, mg/g fresh weight			Table of results	
	Untreated	15 g/m²/month	30 g/m²/month	Treatment	Total pigment mg/g fresh weight
40	2.44	2.49	2.51	untreated	3.19
50	2.81	2.84	2.81		
64	2.91	3.01	3.13	15 g/m²/month	3.41
74	3.42	3.61	3.64		
86	3.77	3.81	3.92	30 g/m²/month	3.70
96	3.63	3.85	4.61		
116	3.43	3.73	4.53		
126	3.23	3.70	4.14	$LSD_{5\%}$	0.006
136	3.05	3.61	4.05		

Calculated value of $LSD_{5\%}$ between the treatments as a function of time: 0.026.

Table 7

Effect of cement dust pollution on the straw yield of maize

Treatment	Straw yield, kg/10 plants (43% water content)	%
Untreated	2.03	100.0
15 g/m²/month	1.97	97.0
30 g/m²/month	1.86	92.0
$LSD_{5\%}$	0.09	4.0

Table 8

Effect of cement dust pollution on the ear yield of maize

Treatment	Ear yield, kg/10 plants (28% water content)	%
Untreated	2.63	100.0
15 g/m²/month	2.44	93.0
30 g/m²/month	2.30	87.0
$LSD_{5\%}$	0.18	7.0

been exposed to pollution for a longer time (Table 4). The intensity of respiration in the polluted plants showed a similar change (Table 5). EWERT (1919) did not find any correlation between cement pollution and the intensity of respiration in the plant.

The total pigment content of the leaves increased non-significantly after a lower degree of pollution and significantly in the 30 g/m^2/month treatment (Table 6). BREDEMANN (1932), CZAJA (1966) and KLINCSEK (1975) obtained similar results with a number of plant species, in spite of the fact that the cited authors pointed out a positive correlation between the level of cement pollution and the reduction in the chlorophyll content of the plant in most species they examined.

The cement-polluted micro-environment provided unfavourable ecological conditions for pollen germination and fertilization [pollen requires a slightly acidic pH to germinate and fertilize (KLINCSEK 1975)]. Therefore the ear (particularly the tip) responded with deficient seed setting to a high rate of pollution by cement dust.

Fertilization was also examined in plants grown in the neighbourhood of the cement works and was found to be nearly identical to that in the experimental plants. The strip of maize field under the dominant dust torch was regarded as polluted, and the strip on the opposite side of the cement works as the control. On harvesting no significant difference in dry weight was found for the lower rate of pollution compared to the control. The high rate of pollution, on the other hand, significantly decreased the ear yield (Tables 7, 8). MALY (1966) obtained similar results with maize.

Conclusions applicable in practice cannot be drawn from the results obtained so far, since cement dust influences the yield by acting on the soil as well as on the plant (SCHEFFER *et al.* 1961, GARBER 1967). An account of investigations in this field will be given in a subsequent paper.

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PROGRESS FROM PHENOTYPIC SELECTION IN ALFALFA SELECTED IN SPACED PLANTINGS AND EVALUATED IN SPACED AND DENSE PLANTINGS

II. FAMILY SELECTION AND SELECTION INDEX

By

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FORAGE CROPS RESEARCH SECTION, FIELD CROPS RESEARCH INSTITUTE, AGRICULTURAL RESEARCH CENTRE, ORMAN, GIZA; AGRICULTURAL RESEARCH INSTITUTE, KOMPOLT

Family selection was applied for yield and related attributes among a number of half-sib progenies of four growth habit types of alfalfa (erect, semi-erect, semi-prostrate and prostrate types, respectively) cultivated in spaced-planted nursery under competitive and non-competitive conditions. Selection for plant height under competition increased the yield of erect and semi-prostrate types more than selection for yield itself did under the same conditions. Selection for dry stem weight of prostrate and semi-prostrate types in the absence of competition was more effective in increasing yield than selection for any other trait either in the presence or in the absence of competition. The selection index computed from genetic variances and covariances estimated in spaced plantings was not valid to give a correct estimation for the genetic advance observed in mass-seeded progeny.

Introduction

The masking effect of soil heterogeneity is more pronounced in the case of quantitative characters like yield and less pronounced in the case of qualitative characters (Fasoulas—Tsaftaris 1975). This fact, coupled with the finding that most characters are correlated, led plant breeders to try another approach to overcome the difficulties brought about by soil heterogeneity. Falconer (1960) suggested that it may be possible to achieve more rapid progress when selecting for a secondary character than for the desired character itself, when the secondary character has a higher heritability than the desired character and the genetic correlation is high. Davis—Buker (1966) concluded that selection based on variables associated with dry weight in alfalfa would be 96% and 109% as effective as selection based on actual dry weight for harvest on July 21st and September 6th, respectively.

The philosophy of this approach is to select for yielding ability indirectly through characteristics less affected by environmental changes but correlated with yield. In this study data are presented from a selection programme for yield and other related characters within alfalfa populations under different levels of competition in relation with trends for improving yield potential by selecting for a character less affected by genotype-environment interaction.

Material and method

On the basis of a total of three cuts per plant for half-sib progenies tested in spaced-planted trials (Part I), the top 20% of progenies were selected for each of the following traits: (1) Dry matter yield, (2) Plant height, (3) Number of stems, (4) Dry stem weight and (5) Dry leaf weight.

To study the effectiveness of family selection for different traits under competitive and non-competitive conditions for the four types of alfalfa under investigation, open pollinated seed of selected families from both wide and close spacing were harvested. The harvested seed was mass seeded in an experiment with a randomized complete block design with 4 replications in a large-sized greenhouse in October 1973.

The original population was used as a measure for the genetic gains due to family selection and was seeded in the experiment from the remaining seed of selected individuals from which the progenies subjected to family selection were derived.

Three cuts were taken and yield data were obtained by weighing the green forage from each progeny; stand counts were made at each cut and the yield was recorded as g/plant.

The expected and observed gains were calculated as in individual plant selection, but the heritability used in computing the expected gains was that estimated from parent-offspring regression, and K was the selection intensity when the top 20% of the half-sib families were chosen. The "t" test was used to compare (1) the yield of progenies for selected families in wide and close spacings, regardless of the character for which selection was made, (2) the yield of selected progenies for certain traits and (3) the yield of the original population and that of selected progenies in both wide and close spacings.

The observed gain was also compared with the expected gain computed from two selection indices. The first index was computed from plant height, number of stems and dry matter yield, while the second index was computed from plant height, dry stem weight and dry matter yield. The expected genetic advance using the selection index was computed from the formula given by ROBINSON *et al.* (1951) as

$$\frac{Z}{P} = b_1 g_1 y_1 + b_2 g_2 y_2 + \ldots + b_n g_n y_n$$

where

$\frac{Z}{P}$ = selection differential in standard units,
b_1 = b value for plant height,
b_2 = b value for stem number in index I, and dry stem weight in index II,
b_n = b value for yield,
$g_1 y_1$ = estimate of genotypic covariance for plant height and yield,
$g_2 y_2$ = estimate of genotypic covariance for stem number and yield in index I, and stem weight and yield in index II,
$g_n y_n$ = estimate of genotypic variance for yield.

Results

The green yield per plant for the progeny of families selected for different characters and for that of the original population was calculated and listed in Table 1. Using the "t" test, comparisons were made between the progeny yield of selected families and close spacings, and between the progeny yield of families selected for different characters. The "t" values are summarized in Table 2. The observed gain from selection for different traits was computed as a percentage of the original population and the values obtained are presented in Table 3. The expected gain was computed as a percentage of the population mean subjected to family selection in both wide and close spacings and the values obtained are presented in Table 4.

Table 1

Green yield per plant for progenies of selected families and the original population

Characters selected for	Spacing under which selection was made	Green yield g/plant for progenies				Average
		Erect	Semierect	Semi-prostrate	Prostrate	
Plant height	Close	22.22	21.93	31.76	24.70	25.15
	Wide	16.44	17.94	31.08	21.53	21.75
Number of stems	Close	18.90	18.41	28.99	31.05	24.34
	Wide	18.12	22.53	27.99	22.09	22.68
Dry matter yield	Close	20.33	22.15	19.10	24.70	21.57
	Wide	16.48	21.83	24.69	25.35	22.09
Dry stem weight	Close	21.24	13.72	22.84	26.55	21.08
	Wide	17.89	18.97	31.19	32.41	25.11
Dry leaf weight	Close	18.91	20.61	24.60	23.78	21.97
	Wide	16.19	20.96	30.20	21.62	22.42
Average	Close	20.32	19.36	25.45	26.16	22.82
	Wide	17.17	20.45	28.88	24.60	22.22
Original population		16.36	22.20	22.84	23.03	21.11

The data presented in Tables 1 and 2 show that the progeny of families selected for plant height in close spacings and those selected for dry stem weight in wide spacings were not significantly superior to the progeny of families selected only for dry matter yield, with an average of 25.15, 25.11 and 22.09 g/plant for the progeny of families selected for plant height, stem weight and dry matter yield, respectively.

A comparison between the progeny yield of families selected with close and those selected with wide spacing, regardless of the character which was selected for, showed that family selection for erect type with close spacing gave a higher yield than that applied with wide spacing (significant difference at the 5% level) when their progenies were tested in solid seeding. The green yield per plant (Table 1) was 20.32 g and 17.17 g from selection with close and wide spacings, respectively. No significant differences were obtained for the other three types (Table 2). The data listed in Table 3 show that the average observed gain from family selection in close spacing was higher than that in wide spacing for erect and prostrate types, and a higher gain was observed from selection in wide than in close spacings for the semi-prostrate type. Selection in the semi-erect type under both spacings was ineffective.

The estimated average gain was 8.1% for selection in close spacing and 5.2% for selection in wide spacing. The highest observed gain in the yield of the erect type came from selection for plant height (36.1%) or dry stem weight

Table 2

Summary of "t" values computed for significant differences between means of treatments

Comparison between means of	"t" values
Progenies of erect type selected under wide and close spacings	3.711*
Progenies of semi-erect type selected under wide and close spacings	0.653
Progenies of semi-prostrate type selected under wide and close spacings	1.748
Progenies of prostrate type selected under wide and close spacings	0.630
Progeny of selections for dry matter yield and those selected for plant height in wide spacings	0.140
Progeny of selections for dry matter yield and those selected for plant height in close spacings	1.268
Progeny of selections for dry matter yield and those selected for number of stems in wide spacings	0.318
Progeny of selections for dry matter yield and those selected for number of stems in close spacings	0.862
Progeny of selections for dry matter yield and those selected for dry stem weight in wide spacings	1.292
Progeny of selections for dry matter yield and those selected for dry stem weight in close spacings	0.180
Progeny of selections for dry matter yield and those selected for dry leaf weight in wide spacings	0.170
Progeny of selections for dry matter yield and those selected for dry leaf weight in close spacings	0.024
Progeny of selections in wide spacings compared with the original population	1.032
Progeny of selections in close spacings compared with the original population	1.113

* Significant at the 5% level of probability.

Table 3

Gains for green yield per plant after one cycle of family selection computed as a percentage of the original population

Character selected for	Spacing under which selection was made	Gains %				Average
		Erect	Semierect	Semi-prostrate	Prostrate	
Plant height	Close	36.1	– 1.3	39.0	7.2	19.1
	Wide	0.4	–19.2	36.0	–6.6	3.0
Number of stems	Close	15.5	–17.1	26.9	34.8	15.3
	Wide	10.7	1.5	22.5	–4.1	7.4
Dry matter yield	Close	24.2	– 0.3	–16.4	7.2	2.1
	Wide	0.7	– 1.7	8.0	10.0	4.6
Dry stem weight	Close	29.8	–38.2	0.0	15.2	–0.2
	Wide	9.3	–14.6	36.5	40.7	8.9
Dry leaf weight	Close	15.5	– 7.2	7.7	3.2	4.0
	Wide	3.3	– 5.6	32.2	–6.2	6.2
Average	Close	24.2	–12.8	11.4	13.5	8.1
	Wide	4.9	– 7.9	26.4	6.8	5.2

Table 4

Expected genetic advance as a percentage of the population mean subjected to family selection from the top 20% of progenies for dry matter yield only

Selected under	Growth habit type			
	Erect	Semierect	Semi-prostrate	Prostrate
Close spacing	21.94	26.15	23.12	0
Wide spacing	4.20	0	0	0

Table 5

b coefficients actually used for selection, and computed from progenies grown in three sowing systems

Sowing system	Growth type	Index I			Index II		
		b_1	b_2	b_3	b_1	b_2	b_3
Solid seeding	Erect	−0.031	−0.102	0.402	0	4.286	−4.286
	Semi-erect	−0.087	1.669	−1.910	0.151	0.382	−0.091
	Semi-prostrate	0.006	0.376	−0.239	0.107	0.230	−0.421
	Prostrate	−0.077	0.449	−0.507	−0.071	− 1.053	0.704
Close spacing	Erect	0.442	−1.441	2.122	0.449	−27.910	14.620
	Semi-erect	0.196	0.194	−1.429	0.265	13.959	−8.997
	Semi-prostrate	0.314	−0.591	−0.058	0.327	5.537	−4.248
	Prostrate	2.248	0	−2.419	2.248	0	−2.419
Wide spacing	Erect	−0.318	−0.290	0.854	0.109	−20.410	12.585
	Semi-erect	2.272	0.069	0.588	2.009	20.450	−10.995
	Semi-prostrate	2.162	−1.212	−1.891	1.260	−5.745	0.924
	Prostrate	1.951	−0.645	7.233	2.439	−6.447	9.543

(29.8%) in close spacing. Selection for other traits was less effective than selection for yield itself, but was higher than the yield of the original population. Selection for any trait in a semi-erect type was ineffective. The increase in yield from family selection in the prostrate type was higher than the original population when selection was made for the number of stems in close spacing (34.8%) or for dry stem weight in wide spacing (40.7%). The highest gain in yield was computed foı the semi-prostrate type when selecting for plant height in both wide (36.0%) and close (39.0%) spacings. Selection for dry stem weight or dry leaf weight in wide spacing gave similar gains.

An attempt was made to compute a selection index from the two spaced-planted nurseries and from solid seeding using genotypic variances and covariances computed from the analysis of variance and covariance. The estimated weights to be given to the characters in the two suggested indices are presented in Table 5.

The genotypic variances and covariances used in calculating genetic gains are presented in Table 6. The advances in yield expected from selecting the top 20% of the progenies on the basis of these indices are given in Table 7.

Table 6

Genotypic variance and covariance used for calculating selection indices, and computed from progenies grown in three sowing systems

Sowing system	Growth type	Index I			Index II		
		g_1y_1	g_2y_2	g_ny_n	g_1y_1	g_2y_2	g_ny_n
Solid seeding	Erect	− 3.0	0	0	− 3.0	0	0
	Semi-erect	− 7.0	1.2	− 0.4	− 7.0	− 0.2	− 0.4
	Semi-prostrate	0.4	0.8	0.2	0.4	0	0.2
	Prostrate	− 5.0	− 1.0	0	− 5.0	0	0
Close spacing	Erect	41.2	− 1.2	5.2	41.2	2.2	5.2
	Semi-erect	11.0	− 5.0	− 4.4	11.0	− 2.2	− 4.4
	Semi-prostrate	36.4	− 9.2	− 0.6	36.4	0.2	− 0.6
	Prostrate	182.6	24.8	41.6	182.6	23.8	41.6
Wide spacing	Erect	−10.0	− 7.0	5.2	−10.0	− 4.6	5.2
	Semi-erect	233.6	134.2	117.2	233.6	81.2	117.2
	Semi-prostrate	−56.4	−132.8	−107.2	−56.4	−63.8	−107.2
	Prostrate	320.0	241.4	218.0	320.0	126.6	218.0

Table 7

Expected genetic advance as a percentage of the population mean subjected to family selection from the top 20% of the progenies, when selection was based on the index for plant height, number of stems (index I) or dry stem weight (index II), and dry matter yield in three sowing systems

Sowing system	Index	Growth type			
		Erect	Semierect	Semi-prostrate	Prostrate
Solid seeding	I	9.11	45.94	13.17	0
	II	0	0	0	15.54
Close spacing	I	107.61	44.13	65.49	290.80
	II	111.68	55.45	62.86	290.80
Wide spacing	I	15.13	116.37	76.67	226.54
	II	61.24	46.43	69.08	264.13

Comparing the gains expected when selection was based on the index for dry matter yield only (Table 4) to that based on the index for dry matter yield, plant height and stem number (Table 7, index I) or that computed for dry matter yield, plant height and dry stem weight (Table 7, index II), showed the absence of any relationship between the expected gains in the three indices in both wide and close spacings. When the indices were computed from spaced nurseries the expected gains were much higher than those computed from solid seeding, and in some cases were twice as much as the population mean.

In many cases, the observed gains showed that the progeny of selections for plant height and stem number were the highest yielding ones. These results are in some degree of agreement with the index computed from solid seeding and based on plant height, number of stems and dry matter yield for the erect and semi-prostrate types.

The observed gains for prostrate type are in some degree of agreement with index II, which was computed from plant height, dry stem weight and dry matter yield in solid seedings.

Discussion

The advance in yield gained from selection for plant height under competition was more effective than selection for yield itself in improving the yield of both erect and semi-prostrate types. Selecting for dry stem weight under non-competitive conditions increased the yield of semi-prostrate types. This result is in good agreement with that found by LORENZETTI—MONATTI (1964), who concluded that yield as a whole had low heritability value and selection for highly heritable traits such as plant height and dry stem weight would lead to more rapid progress than selection for yield itself.

It could be concluded that selection for plant height in erect and semi-prostrate types in the presence of competition made the genetic differences in this character more pronounced and the efficiency of selection more reliable. On the other hand, evaluating the dry stem weight of prostrate and semi-prostrate types in the absence of competition minimized the differences between half-sib progenies under selection for this characteristic more than other characters.

A similar conclusion was arrived at by RAMMAH—BŐJTÖS (1977). Working with vegetative clones of alfalfa they concluded that plant height was the least susceptible characteristic for competition and the number of stems per plant and stem thickness were the most important factors affecting the performance of selected genotypes in the space-planted nursery when transferred to drill conditions.

It could be concluded from the results obtained in parts I and II of this study that it is possible to select individual plants on the basis of plant height and/or dry stem weight from a population divided into groups, each consisting of a limited number of plants sown under simulated mass-seeding; open pollinated progenies of selected plants have to be evaluated in swards so that the most productive progenies can be selected.

Genetic variance components appeared to be changeable under different levels of competition (RAMMAH—BUGLOS 1976). Therefore, *b* coefficients, and genetic variances and covariances based on data from spaced-planting, were not precise enough to give a selection index which could be used in alfalfa breeding programmes. Selection indices computed from data in solid seeding gave expected gains relatively close to those observed in solid seeding from selection under competitive conditions.

In conclusion, the deduction leading to the superiority of indices over other methods of selection and the correctness of the estimated superiority of one index over another are dependent upon having correct values for both phenotypic and genotypic variances and covariances.

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VARIA

THE MORPHOLOGICAL FEATURES AND PHYSIOLOGICAL SIGNIFICANCE OF THE PEPTIDERGIC NEUROSECRETORY NEURONS IN INSECTS

Neurosecretion as a peculiar manifestation of the nervous system was discovered quite a long time ago (SCHARRER 1928). Nowadays, when neurosecretion has been widely accepted as a universally existing "coupling" process between the nervous and endocrine system, its peculiar character seems to be very common. The early brilliant discoveries concerning this phenomenon, made by NANSEN (1887), HAMAKER (1898), METALNIKOFF (1900), BRETSCHNEIDER (1914) and SPEIDEL (1919, 1922), only became valuable in the light of this new concept.

The acceptance of neurosecretion as a fundamental biological process was not obvious for a long time; the conception has been born in the midst of rejections and contradictions. "We have just heard some very interesting things, — and also a great deal of nonsense". These not very polite words were addressed to E. Scharrer in 1954, when he presented his concept on neurosecretion (KNOWLES 1974). The root of the matter is first, whether neurons which are specialised primarily for the synthesis, transport and release of certain secretory substances exist, and secondly, if they carry out this typical glandular activity, how can they preserve their nervous characteristics? The question is no doubt justified, since the transformation of true nerve cells: the sympathicoblasts, to chromaffin glandular cells is well known in the adrenal gland of vertebrates.

As regards the above-mentioned question, a large number of experiments have been made to clarify the complexity of neurosecretion. Morphological studies raised the phenomenon of neurosecretion, providing several proofs concerning the occurrence of neurosecretory material (GABE 1966).

In the course of biochemical studies several neurohormonal "factors" were isolated and chemically analysed from the neuroendocrine organs (see reviews by GAINER *et al.* 1977, FRONTALI—GAINER 1977, WALKER 1978). The physiological experiments: extirpation, transection, degeneration and regeneration, significantly contributed to the elucidation of the function of neurosecretory systems (DELLMANN 1973). On the basis of the large amount of information yielded by different methods, it became possible to create the definition of neurosecretion. The criteria of the definition were expressed rather differently by different scientific teams and the definition has been changed from time to time. A great many people stressed the cytological evidence (MADDRELL 1967, VAN DER KLOOT 1960). Others stated that the axon of the neurosecretory neuron had to liberate its messenger into the circulatory system, i.e. the neuron is not in direct contact with the effector cells (KNOWLES—CARLISLE 1956). Some people believe that the presence of the neurosecretory elementary granules is primary (FINLAYSON—OSBORNE 1968). Morphologically the neurosecretory system is composed of secretory neurons whose axon terminals represent the mean place of storage and liberation of neurosecretory materials (DELLMANN 1973). According to Scharrer "a valid definition of the very concept of neurosecretion requires a comprehensive spectrum of information, including that on the phylogenetic origin of neuroglandular activity" (SCHARRER—WEITZMAN 1970). Neurosecretory terminals together with blood vessels as well as glial cells usually form the so-called "neurohemal organ", as for example the neurohypophysis of vertebrates, the urophysis of fish and the corpus cardiacum of insects (DELLMANN 1973). Neurosecretory neurons synthetise different chemical mediators which are liberated into the circulatory system, or are transported via neurosecretory fibres to the effector cells and released through simple or synaptoid contacts (SCHARRER—WEITZMAN 1970). The chemical mediators were octa-peptides in the "classical" neurosecretory neurons, and these possess true hormonal characteristics (DELLMANN 1973). However, today it is well known, that secretory neurons may contain short polipeptides, simple peptides and different monoamines (norepinephrine, dopamine, serotonine) too (GABE 1966, FUXE—HÖKFELT 1969, HÖKFELT—FUXE 1972, OKSCHE *et al.* 1972, RODRIGUEZ 1972, WEINER *et al.* 1972).

Comparing the neurosecretory system of vertebrates and invertebrates it may be established that there is no basic difference between them. The problems are also exactly the same in the two animal groups, namely:

1) the simultaneous glandular and neural character of the neurosecretory cells,
2) the nature of the afferent control mechanisms,
3) the chemical composition and release mechanism of the neurosecretory mediators,
4) the extraneuronal pathways through which the neurohormones reach the target cells,
5) the mode of action of neurosecretory mediators on the effector cells.

As regards the occurrence of neurosecretory neurons they appeared to be present in every multicellular animal. Different types of neurosecretory neurons have already been described on the basis of light microscopical histochemistry (GABE 1966). Recently, more and more neurosecretory cells and systems have been found (OSBORNE *et al.* 1971, RAABE *et al.* 1972, SCHOONEWELD 1974a, b). Nevertheless, the present data are not sufficient for a final classification.

Neurosecretion in insects

The first description of neurosecretory neurons in insects was given by WEYER (1935) in the brain of the honey-bee. Most of the neurosecretory cells of the insect are localised in the central (and peripheral) ganglions, and usually a well-defined neurohemal organ is developed behind the brain. Two glands, the corpora allata and the prothoracal gland, both of ectodermal origin, are found in the head and prothorax, respectively, and are in a close functional association with the neurosecretory system. Among the neurosecretory neurons of insects, the protocerebral neurons have been most carefully studied. These cells are generally located on two anatomically distinct areas of the protocerebrum; dorsally in the pars intercerebralis and dorsolaterally as lateral neurosecretory cells (GORBMAN—BERN 1962, BERN—HAGEDORN 1965, TOMBES 1970). Ultrastructural and histochemical studies showed a great similarity between the protocerebral neurosecretory system of insects and the neurosecretory cells of the nucleus supraopticus and n. paraventricularis of vertebrates. This similarity raised the possibility that protocerebral neurosecretory cells of insects may also synthetise peptidic neurohormones. The morphological and cytochemical characters of the neurosecretory cells, as well as their size and number, may be very different. A different number of neurosecretory cells were found in the tritocerebrum (RAABE 1959, MASON 1973, GIRARDIE 1976), in the subesophageal ganglions (SCHARRER 1941, RAABE 1959, DÜRNBERGER—POHLHAMMER 1978), in the ventral ganglions (JOHANNSON 1958), in the stomatogastric (FÜLLER, 1960, TOMBES—MALONE 1977), and in other ganglions.

The axons of the medial neurosecretory cells form the nervi corpori cardiaci I, and the lateral cells the nervi corpori cardiaci II, and these transport the neurosecretory material

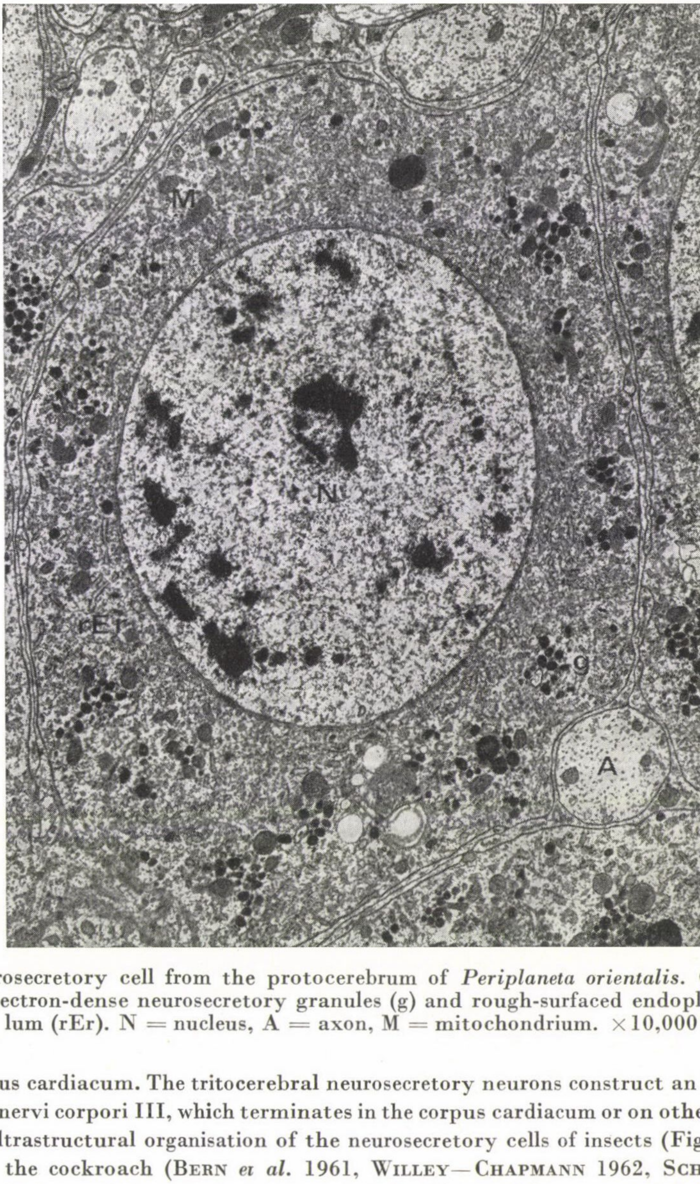

Fig. 1. Neurosecretory cell from the protocerebrum of *Periplaneta orientalis*. Cytoplasm is filled with electron-dense neurosecretory granules (g) and rough-surfaced endoplasmic reticulum (rEr). N = nucleus, A = axon, M = mitochondrium. ×10,000

into the corpus cardiacum. The tritocerebral neurosecretory neurons construct an axon bundle, the so-called nervi corpori III, which terminates in the corpus cardiacum or on other target cells.

The ultrastructural organisation of the neurosecretory cells of insects (Fig. 1) was first described in the cockroach (Bern et al. 1961, Willey—Chapmann 1962, Scharrer 1965) and in the stick insect (Meyer—Pflugfelder 1958, Heuson-Stiennon 1962). There was no comparison between light and electron microscopical observations in these experiments; only Bloch *et al.* (1966) made such a comparison in the case of Calliphora erythrocephala.

Neurosecretory cells in the brain and other ganglia

A detailed study has been made by Bassurmanova—Panov (1967) on protocerebral neurosecretory cells of silk-worm larvae. On the basis of their light and electron microscopical studies it has been suggested that the A′ cells identified in the light microscope contained both electron-transparent vesicles and a lesser number of electron-dense granules (diameter: 1000—3000 Å). The so-called A' cells contained only a large number of electron-dense granules. In the neuropile of the brain the authors have observed nerve fibres in which the same vesicles and electron-dense granules were present as in the neurosecretory cells. A great number of neurosecretory fibres have also been observed in the corpus cardiacum as well as in the corpora allata. As regards the electron-transparent vesicles in the neurosecretory cells, some doubt has been raised as to whether they are true neurosecretory granules or artifacts? Since these granules have been observed (SMITH—SMITH 1966, BRADY—MADDRELL 1967) in the axons of the neurohemal organs of several insects, BASSURMANOVA—PANOV (1967) suggest that this type of vesicles represents a certain type of neurosecretory cell.

The neurosecretory system of insects has been extensively investigated at ultrastructural level by several authors since the sixties. SCHOONEWELD (1974a) has described 7 types of neurosecretory cells in the medial and lateral areas of the brain of the colorado potato beetle. According to him, the A, A_1, B, C and E types of neurosecretory cells are present in the medial part of the brain. In the A type cells, electron-dense granules were found, and their average diameter was about 1250 Å. 2100 Å was the average diameter of neurosecretory granules in the A_1 cells, and their electron density was lower than in the A cells. Dense-core type neurosecretory granules were present in the so-called B cells; their average diameter proved to be 1200 Å. In the C type neurons the diameter of the neurosecretory vesicles was 1700 Å. Dense-core type secretory granules have also been observed in the E type neurosecretory cells.

The ultrastructural characteristics of the lateral neurosecretory cells of the colorado potato beetle proved to be rather heterogeneous. Both the large electron-dense granules and the smaller dense-core granules were usually found in these neurosecretory cells (L_B type neurons). As regards the 7 morphologically different neurosecretory cells, SCHOONEWELD (1974a) has suggested that they represent 7 functionally different cell types. Studying the pathways of these neurosecretory neurons, SCHOONEWELD (1974b) established that most of the branches of the medial cells are carried by the nervi corporis cardiaci I to the corpus cardiacum; however, the collaterals of A and A_1 type cells appeared to be present in the protocerebral neuropile too. The local "varicosities" of these axons were often closely attached to the fibres of ordinary neurons. At the site of these contacts electron-lucent vesicles are usually accumulated and the electron-dense clefts of the ordinary synapses were also present. Microvesicles with a diameter of 400 Å have been observed in practically every axon of neurosecretory cells (SCHOONEWELD 1974b). As regards the junctional complexes described above, SCHOONEWELD (1974b) has concluded that they are true axo-axonic synapses, where the neurosecretory fibres were usually post-synaptically arranged and might be involved in the transport of afferent signals from the neuropile to the neurosecretory cell.

Neurosecretory fibres or terminals may be arranged presynaptically too in the neuropile of the brain of the colorado potato beetle (SCHOONEWELD 1974b). In this case certain messengers may leave the axon swellings, because the neurosecretory fibres practically innervate some effector cells via the neighbouring nerve processes (see neurosecretomotor junctions; BERN 1966, MILLER 1975). Such types of fibres as well as synaptic junctions have also been observed in the neuropile of the protocerebrum of the locust (Figs 2—3).

Neurosecretory terminals in presynaptic positions have also been described by UDE *et al.* (1978) in the frontal ganglion of *Periplaneta americana*. In contradicton to NANDA *et al.* (1973), UDE *et al.* (1978) state that no peptidergic neurons were seen in the frontal ganglion of the *Periplaneta americana*, and that cells containing dense-core vesicles represent aminergic neurons. At the same time, however, both peptidergic and aminergic terminals may occur in the neuropile of the frontal ganglion, but it is not clear what their origin is.

On the basis of the close morphological contacts between the two (peptidergic and

Fig. 2. Synaptic neuropile in the protocerebrum of *Locusta migratoria.* "Empty" (E), densecore vesicles (dc) and neurosecretory granules (g) are present in the different axon terminals. ×30,000

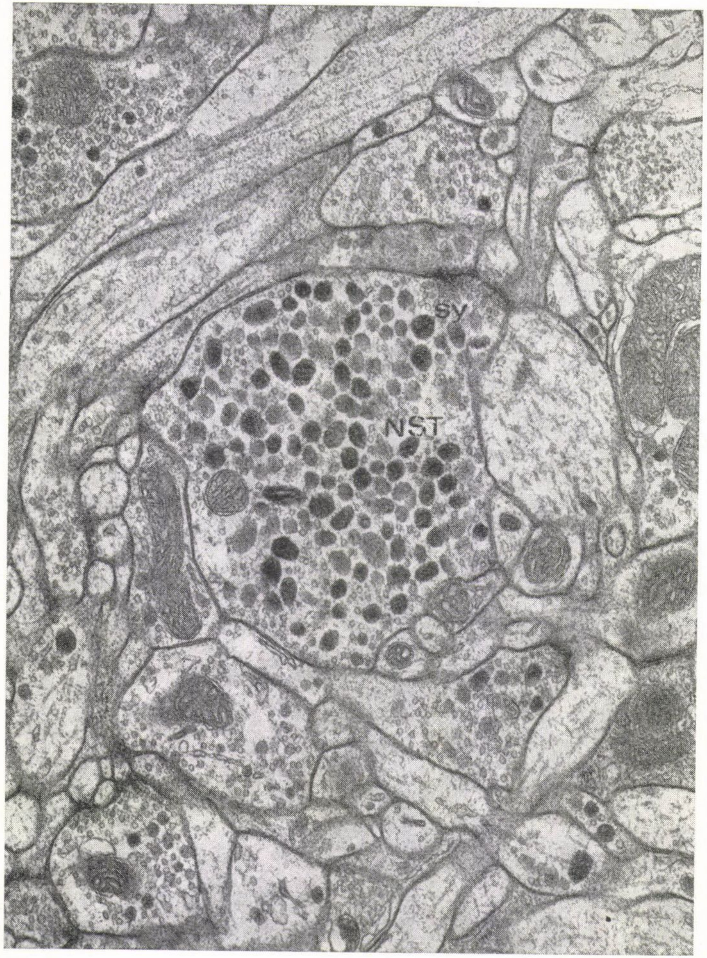

Fig. 3. The same as Fig. 2, but the neurosecretory terminals (NST) also contain empty vesicles. Moreover, several synaptic specializations, both pre- and post-synaptic (sy) can be found on the surface of the terminals. ×30,000

aminergic) terminals, UDE *et al.* (1978) suggested that these synapses were comparable with the "peptidergic synapses" of vertebrates (STERBA 1974).

As regards the presence or absence of neurosecretory cells in the frontal ganglia, three recent ultrastructural studies have demonstrated the presence of them in two *Lepidoptera: Manduca sexta* (BORG *et al.* 1973, BELL *et al.* 1974) and *Diatraea grandiosella* (YIN—CHIPPENDALL 1975). Both the above-mentioned authors, as well as TOMBES—MALONE (1977) attempted to correlate the activity of the neurosecretory cells with the introduction, maintenance and termination of pupal diapause.

Corpus cardiacum and other neurohemal organs

There is no doubt that *corpus cardiacum* is the primary neurohemal organ in insects (SCHARRER 1952). However, it is easy to find several other organs in insects, which can fulfil the criteria of the neurohemal organ (TOMBES 1970). The *corpus cardiacum* develops from the so-called stomodeal wall, as the dorsal sympathetic nervous system, thus the organ seems to be a modified ganglion. The *corpus cardiacum* is composed mainly from swollen axons (Fig. 4) which have originated from the neurosecretory cells of the protocerebrum. Neurosecretory materials are transported via these axons into the corpus cardiacum; here they are stored for a shorter or longer time, and after an impulse they are liberated into the haemolymph. Besides the neurosecretory axons, neurosecretory neurons, glandular cells (Fig. 5), glial cells and connective tissue are also found in the *corpus cardiacum*. The *corpus cardiacum* has been thoroughly studied in the last two decades. Its ultrastructure was described in 1961 (WILLEY—CHAPMAN 1962), and after this a series of publications can be found in the literature (SCHARRER 1963, NORMANN 1965, SMITH—SMITH 1966, CAZAL *et al.* 1971, AGGARWAL—KING 1971, MASON 1973, JUBERTHIE-JUPEAU—JUBERTHIE 1973, JUBERTHIE—BOUVET 1975, SCHARRER—WURZELMANN 1978). In the course of electron microscopical studies NORMANN (1965) established that neurosecretory axons compose the medullary part of the *corpus cardiacum* and a large number of synaptic contacts may be found here, thus this area corresponds to the neuropile of the *corpus cardiacum*. At the marginal part (periphery) of the organ, neurosecretory cells are located which send their axons into the neuropile and terminate in the haemocoel. In the neurosecretory neurons and axons of the *corpus cardiacum* it is possible to find all those types of granules and vesicles which were found in the protocerebral neurosecretory cells (SCHOONEWELD 1974b). Most of the authors are agreed that neurosecretory granules are produced in the Golgi apparatus, and are released by exocytosis into the haemocoel or the extracellular stroma (NORMANN 1965, NORMANN 1976, JUBERTHIE—BOUVET 1975, SCHARRER—WURZELMANN 1978). The empty synaptoid vesicles in the neurosecretory terminals most probably represent a membrane-retrieval endocytotic process of the terminals rather than true synaptic vesicles (SMITH 1970, SCHARRER—WURZELMANN 1978). The number of neurosecretory fibres is rather variable in the *corpus cardiacum* (AGGARWAL—KING 1971), but among the total of 50 axons about 30 axons terminate in the *corpus cardiacum*, and the other 20 in the *corpora allata*. A great number of neurosecretory axons may be found on the surface of the glandular cells of the *corpora allata* as well as in the intercellular areas (TOMBES—SMITH 1970, 1971). Synaptoid structures have also been observed in close morphological association with *corpora allata* cells (TOMBES—SMITH 1971, SCHARRER 1974). The same neurosecretory innervation has been found in the *Locusta migratoria* (Fig. 6). The release site is detectable between two contiguous axon profiles (→) where several empty vesicles are accumulated, and presynaptic ribbons are also present.

Another neurohemal organ, the *nervus corporis allati II*, has been described by WEBER—GAUDE (1971) in *Acheta domesticus* between the *corpora allata* and the subesophageal ganglion.

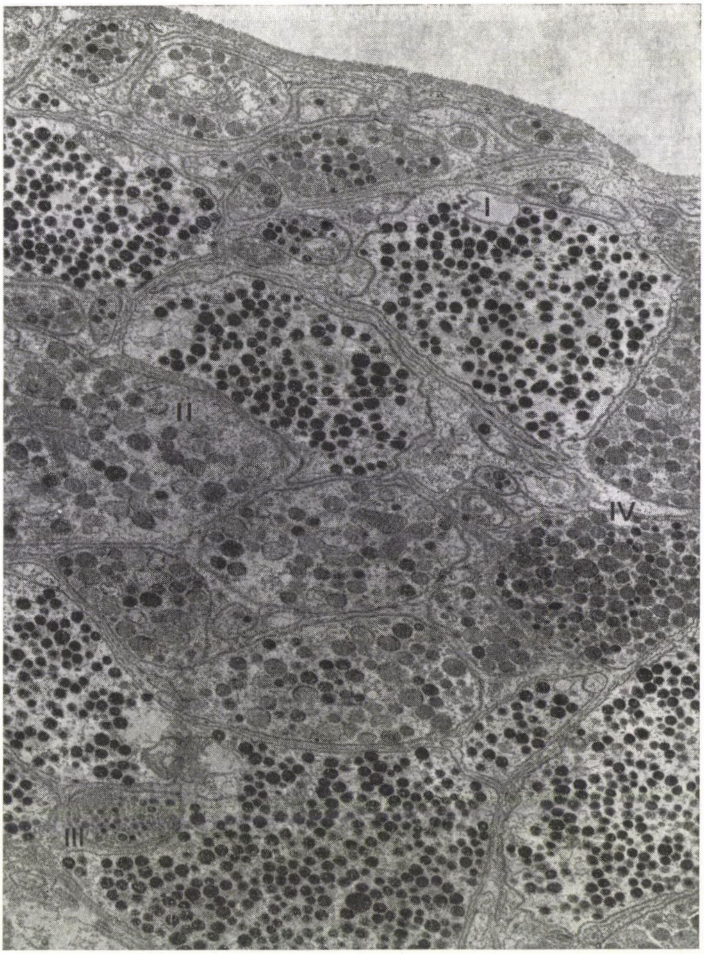

Fig. 4. The neuropile of the *corpus cardiacum* of *Locusta*. Different types of axons. Type I: Large spherical, electron-dense granules. Diameter about 1800 Å. Type II: Poorly preserved, moderately electron-dense granules. Diameter about 3000 Å. Type III: Small, spherical electron-dense granules + empty vesicles. The diameter of the dense granules is about 1000 Å. Type IV: Mixed population of moderately electron-dense granules + small electron-dense granules. ×15,000

Three types of neurosecretory granules were found in this neurohemal organ; large, electron-dense granules, dense-core vesicles and granules with moderate density. A special neurohemal organ, the so-called paraganglionic plates of the harvestman, has been identified on the basis of elementary granules by JUBERTHIE—JUBERTHIE-JUPEAU (1974). A thick neural lamella, a blood sinus, glial cells and 7 different axons were found in this paraganglionic plate. JUBERTHIE—JUBERTHIE-JUPEAU (1974) have suggested that the release of neurosecretory granules may take place not only by exocytosis but also by the disintegration of the large granules in the C type of axons.

Neurosecretory axons full of electron-dense granules have been frequently observed in the haemocoel of the prothoracal gland of *Galleria mellonella* (Fig. 7a). In a very few cases a

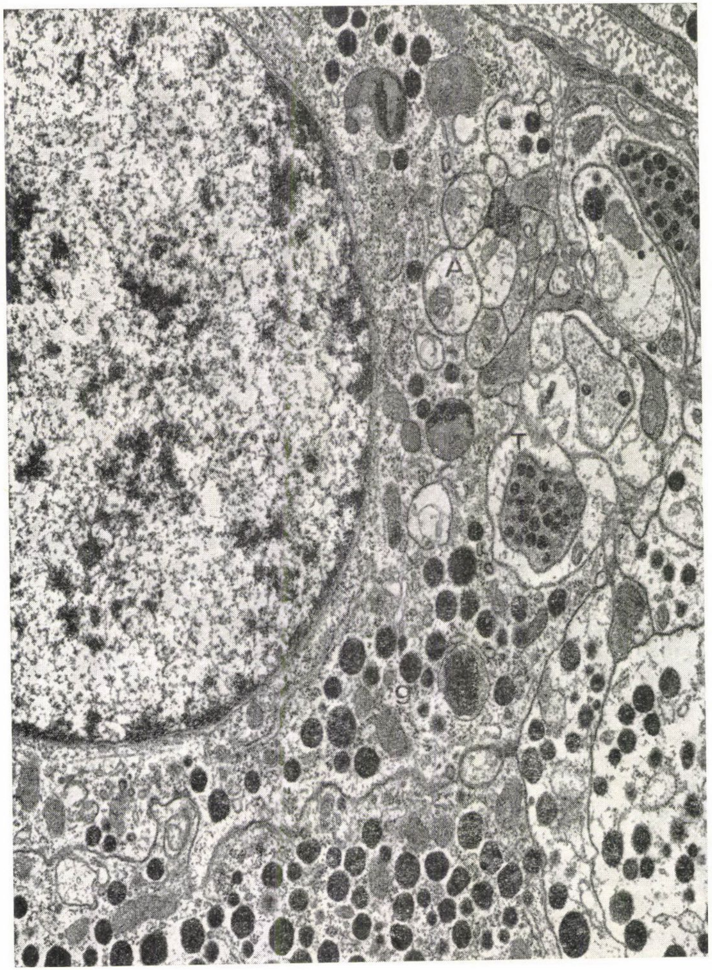

Fig. 5. Endocrine cell in the *corpus cardiacum.* Large electron-dense granules (g) and cytosomes (c) characteristic of these cells. Axons (A) and terminals (T) can be seen beside the cell. ×20,000

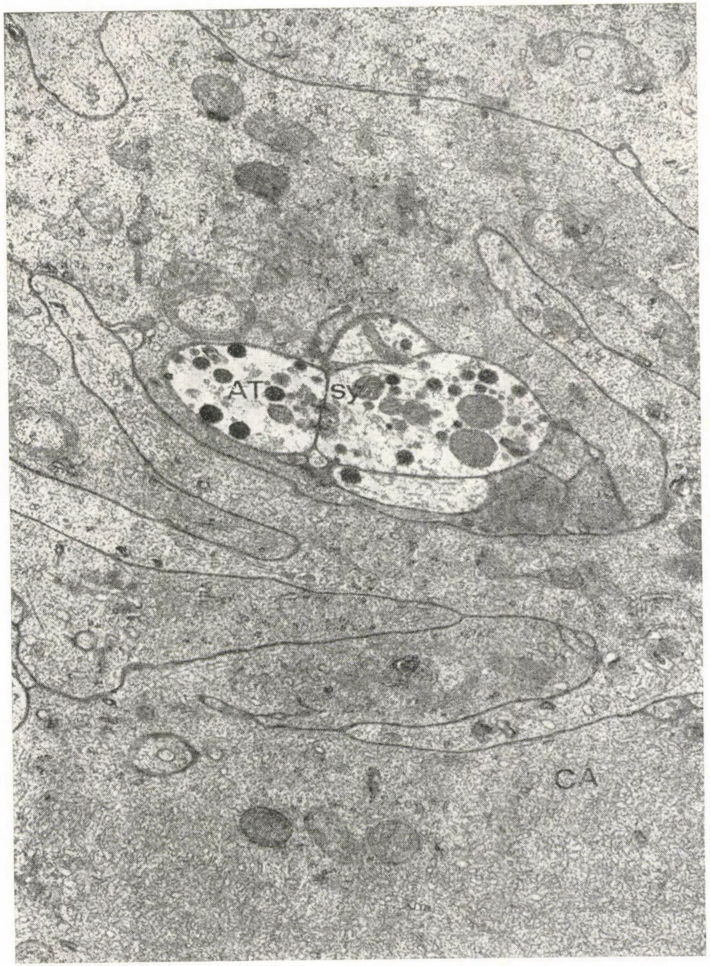

Fig. 6. Glandular cells (CA) and axon terminals (AT) from the *corpora allata* of *Locusta migratoria.* Axolemma lie close to the membrane of allata cells, but synaptic elements (sy) are only present between the axolemma. ×20,000

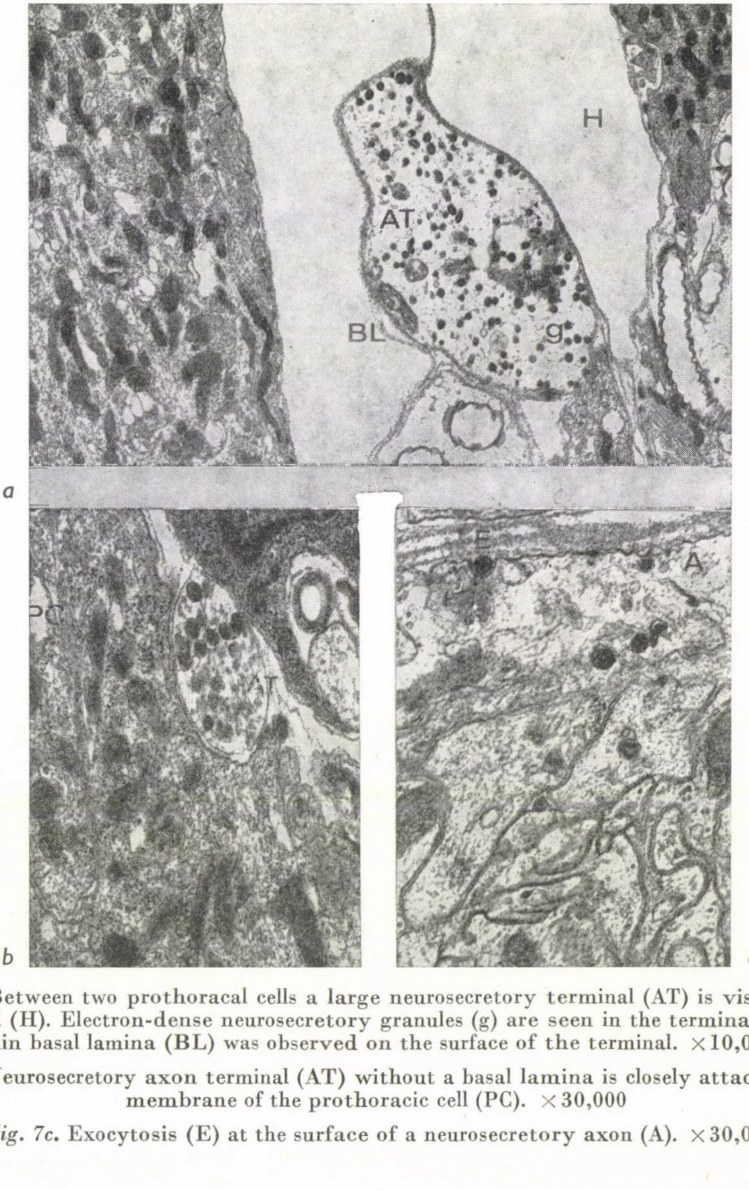

Fig. 7a. Between two prothoracal cells a large neurosecretory terminal (AT) is visible in the haemocoel (H). Electron-dense neurosecretory granules (g) are seen in the terminal. A rather thin basal lamina (BL) was observed on the surface of the terminal. ×10,000

Fig. 7b. Neurosecretory axon terminal (AT) without a basal lamina is closely attached to the membrane of the prothoracic cell (PC). ×30,000

Fig. 7c. Exocytosis (E) at the surface of a neurosecretory axon (A). ×30,000

close morphological association was also found between the neurosecretory axon and the glandular cells (Fig. 7b) and rarely, the morphological evidence of exocytosis was also detectable at the surface of these neurosecretory axons (Fig. 7c). Neurosecretory axons and terminals are quite common in the rectum of the *Locusta* (Fig. 8). Until now no "classical" neurosecretomotor junctions could be found between the muscle fibres and the neurosecretory axons, but a great number of large neurosecretory granules were found in the varicosity of the axons, and small synaptoid structures were also detectable in the vicinity of the visceral muscle (Fig. 9).

Fig. 8. Muscular layer (M) from the rectum of the *Locusta migratoria*. Not far from the muscle a neurosecretory axon terminal (AT) is found in a small axon bundle (A). Empty vesicles and electron-dense neurosecretory granules (g) are present in the terminal. S = synaptoid. ×10,000

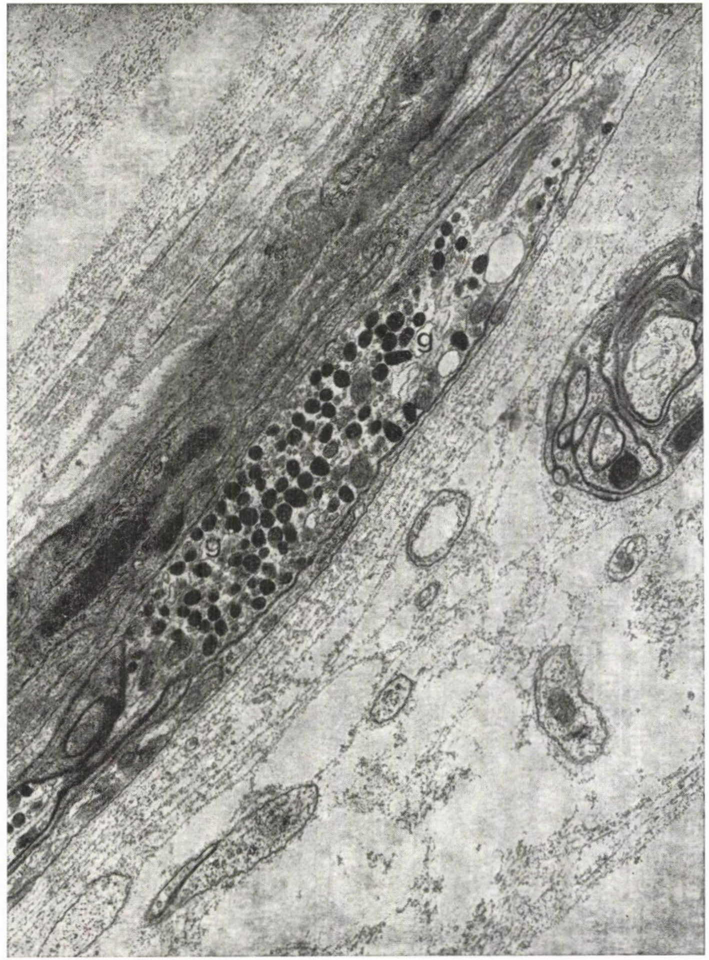

Fig. 9. Polymorph, electron-dense neurosecretory granules (g) are usually characteristic of varicosities of neurosecretory axons in the rectum of *Locusta migratoria*. ×20,000

Possible structural-functional correlations

The neuroendocrine systems of insects have been thoroughly studied not only morphologically but also with biochemical and physiological methods (GERSCH 1975, GOLDING 1974, GOLDSWORTHY—MORDUE 1974, TRUMANN—RIDDIFORD 1974). In most cases, the biologically active substance proved to be peptide in the neurosecretory neurons (FRONTALI—GAINER 1977), so it is not surprising that nowadays it is very common to speak of "peptidergic" neurons even on the basis of morphological characteristics (AROS *et al.* 1977, WARTON—DUTKOWSKI 1978). This opinion is no doubt supported by other results too; several proofs have been obtained from studies on vertebrates (see the review by WALKER 1978) that at least 10 peptides may serve as transmitters in the central nervous system. In contradiction of this, only BROWN (1975) has proved that proctolin, a pentapeptide, may serve as a transmitter in insects in the hindgut of *Periplaneta americana*. Proctolin seems to be present in electron-dense granules (diameter 1000—2000 Å) in the axons of the proctodeal nerve of the cockroach (BROWN 1975). These granules are very similar morphologically to those which have been found in the peptidergic terminals of the hypothalamus of the cat (WALKER 1978). In relation to this fact the question arises, what are the criteria of a peptidergic neuron or terminal? The minimal criterion is that the biological effects of the active factor (or hormone) may be destroyed by proteases (FRONTALI—GAINER 1977). Of course besides this minimal criterion the active factor has to fulfil several other physiological and biochemical criteria as a possible neurotransmitter (PICHON 1974). The first thing that needs to be said is that the term "peptidergic" will be used on the basis of the minimal criterion. After this short morphological review of the mean neurosecretory system of insecta, an attempt will now be made to describe some possible structural-functional correlations.

Morphogenetic hormones

Of course the description of a structural-functional correlation is not easy, since the current literature is full of contradictory results and not satisfactorily proved "beliefs". In the review by GOLDSWORTHY—MORDUE (1974), for example, the authors undoubtedly state: "in insect, polypeptide or peptide hormones are produced by neurosecretory cells or glandular cells associated with the neuroendocrine system". If this general conclusion is applied to the brain hormone of the insecta, for example, it can be established that it is not exactly true. The first crude extract from the brain of *Bombyx mori* proved to be lipoid (KOBAYASHI—KIRIMURA 1958). Since this experiment a confused and long-lasting discussion has been in progress (GOLDSWORTHY—MORDUE 1974, FRONTALI—GAINER 1977) and now it is believed that the hormone is a glycoprotein. The morphogenetic role of the brain hormone was discovered quite a long time ago (WILLIAMS 1947). According to the "classical scheme", brain hormone is synthetized in the protocerebral neurosecretory neuron and is released into the blood and acts on the prothoracic glands. The prothoracic glands are stimulated to produce ecdyson, a hormone whose accumulation in the blood triggers a series of event culminating in a moult (JUDY 1974). If it is accepted that brain hormone acts via the blood on the prothoracal gland the question arises: what is the role of those peptidergic axons which were found to be in the vicinity of glandular cells? Besides brain hormone the protocerebral neurosecretory cells also synthetise the so-called "blood-borne" factor (COTTRELL 1962). Later this factor was called "bursicon" (FRAENKEL—HSIAO 1965) and it was found not only in the brain but also in the ventral ganglions, as well as in the *corpus cardiacum*. Chemically, bursicon seems to be a peptide or protein (FRAENKEL—HSIAO 1965) and it controls the colouring process of the cuticula during moulting. Moreover, it regulates the permeability of the cell membrane of the haemocytes (POST 1972).

Kinetic hormones

Several data confirm that hormones and factors produced by the cerebral and medial neurosecretory systems are implicated in the regulation of urine formation in insects (MADDRELL 1963, MORDUE 1969, GERSCH 1969, PILCHER 1970). Diuresis was increased not only by cerebral extracts, but extracts dissolved from the mesothoracic and abdominal ganglions and from the corpus cardiacum also proved to be effective (FRONTALI—GAINER 1977). According to MADDRELL (1966), the diuretic hormone is produced in the distal part of the mesothoracic ganglion, where swelling axon terminals store the hormone-containing electron-dense granules, and from these the hormone is liberated into the haemolympha. It is not surprising that the target organ of neurohormones which act on diuresis is the Malpighian tubule, where there does not appear to be any innervation, and the tubules are immersed in the neurohormone-containing haemolympha (MADDRELL 1966). The chemical nature of the diuretic hormone was recently clarified (GOLDBARD *et al.* 1970); the hormone is a peptide, with a molecular weight over 30,000 daltons. According to some authors (ASTON 1975, MADDRELL—GEE 1974) cAMP acts as a second messenger on the diuretic hormone.

Neuropeptides that act on the heart

In 1953, Cameron established that an extract from the *corpus cardiacum* is capable of increasing the frequency of the heart-beat of semi-isolated hearts, if the extract was made from animals of the same species (CAMERON 1953). The cardioaccelerant factors were called neurohormones C and *G* by UNGER (1957).

Four different cardioaccelerant factors were separated by GERSCH *et al.* (1960) from the *corpus cardiacum* of the cockroach. First DAVEY (1961) suggested that the active factor might be a peptide. In the 60s and 70s several cardioaccelerant factors were isolated from different organs of insects and were studied chemically and physiologically (BROWN 1965, GERSCH—STÜRZEBECHER 1967, NATALIZI *et al.* 1970). Most of these substances proved to be peptides with low molecular weights. From the homogenate of the *corpus cardiacum* EVANS (1962) prepared blocks for electron microscopy and found that the cardioaccelerant factor was in close association with the electron-dense granular fraction. These isolated granules appeared to be very similar to those which were found in the intact *corpus cardiacum* (EVANS 1962). This type of neurosecretory granules was also observed in those terminals which formed synapses on the muscle fibres of the heart (NORMANN 1965, JOHNSON 1966). From the results of the above studies it can be concluded that the mediators of the neurosecretory cells may be transported directly via nerve terminals to certain effector cells (FRONTALI—GAINER 1977). At the same time some authors (NORMANN 1972, MILLER 1975) fail to support the opinion that neurohormones have a direct regulating effect on the heart-beat of insects.

Neurosecretory (neurosecretomotor) innervation

In the visceral muscle of insects neurosecretory terminals have been observed where the diameter of the secretory granules was less than 1500 Å (ADAMS *et al.* 1973, MILLER—ADAMS 1974). These authors state that these so-called "neurosecretomotor junctions" are formed between the B type, aminergic neurosecretory axons and certain muscle fibres. B type neurosecretory axons, with electron-dense granules were also found to innervate the muscles investing the spermatheca of *Periplaneta americana* (GUPTA—SMITH 1969). Recently MILLER *et al.* (1979) have observed such nerve terminals in the alary muscle of the locust, where large, presumably peptidergic neurosecretory granules (larger than 1500 Å) were also present.

In the rectum of the blowfly two types of axons were seen; in the first type the diameter of the granules was about 1000—3000 Å, while in the second type of axons the diameter of the granules was smaller, about 1000—1500 Å (GUPTA—BERRIDGE 1966). The terminals of these axons might be found in the medullary part of the rectum, but no synaptoid structures and synaptic vesicles were seen in them. GUPTA—BERRIDGE (1966) suppose that these axons correspond to A type peptidergic axons, which are thought to play an active role in the regulation of the rectal function, by the liberation of antidiuretic hormones.

In the ventral-intersegmental muscle of *Rhodnius prolixus*, ANWYL—FINLAYSON (1973) observed axons which terminated in ordinary synapses, and electron-dense neurosecretory granules were seen in the terminals. The authors suggested that nerve endings of this type were capable of performing motor and neurosecretory functions simultaneously.

Neurohormones that act on the metabolism of insects

Extracts from the *corpus cardiacum* significantly increased the concentration of the trehalose in the haemolymph of *Periplaneta* (STEELE 1961, 1963) and at the same time the glycogen decreased in the fat body. According to Steele, a "hyperglycaemic" peptide is present in these extracts, which, similarly to the catecholamines in the vertebrate liver, act on the phosphorilase, and these enzymes catalyse the transformation of glucose phosphate to trehalose. Hyperglycaemic hormone is synthetised in the protocerebral neurosecretory cells, is transported to the *corpus cardiacum*, is liberated into the haemolymph and, via the circulation, acts on the carbohydrate metabolism (FRONTALI—GAINER 1977). Neurohormones of the *corpus cardiacum* can also influence the lipoid metabolism of insects, especially during flight (MAYER—CANDY 1969).

On the basis of morphological, biochemical and physiological data an effort was made to give a short review of the structure and function of the neurosecretory cells of insects. It can be established that research is constantly rich in results in the field of neurosecretion, yet basically important questions are still without answers. In the future researchers must first of all solve the problem of the simultaneous morphological, biochemical and physiological identification of neurosecretory neurons, after it becomes possible to find the neuronal and neuroeffector connections, because only this knowledge will lead to an understanding of the various physiological roles of neurosecretory neurons in insect life.

Such efforts were made by BARKER (1977), who suggested that the molluscan nervous system contains giant neurons which synthetize a variety of low molecular-weight proteins and peptides. Since some of these cells contained large granules, such as were found in the vertebrate magnocellular system, it has been suggested that the cells are neurosecretory. On the basis of his experiments, BARKER (1977) postulated that these giant neurosecretory neurons might generate endogenous bursting pacemaker activity and could regulate the water content in the sea mollusc. It is also very probable that the snail utilises naturally occurring peptides similar to lysine vasopressin to regulate in a long-term manner the membrane properties and electrical excitability of this cell (BARKER 1977).

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STRUCTURE OF THE HOST PLANT CENOSIS OF A RED PEPPER STAND

To ensure efficient protection for cultivated plants and to attain larger yields it is important to discover the structure and operation of the agricultural ecosystem in question. This requires a knowledge of the specific composition and quantitative conditions of the group of animals living there, of the relationship between them, in a word: their role in the biocenosis. No really effective, all-out protection can be contemplated without such knowledge. Red pepper, as one of Hungary's most important export vegetables, deserves special attention because of the ever rising demand and the increase in the production area. Excellent possibilities for this are offered in the Szeged area, one of the largest paprika-growing regions of Hungary. The present paper is aimed at revealing the changing species composition, abundance and dominance conditions of the host plant cenosis.

The literature has so far dealt primarily with pests. SZIRMAI (1941) mentions *Myzus persicae* Sulz., *Doralis fabae* Scop. and *Doralis frangulae* as virus vectors spreading diseases including that known as "újhitűség". He first found green-fly aphids in the second half of June. These became general in the middle of July and occurred in masses at the beginning of August. Besides *Myzus persicae* Sulz. SZALAY-MARZSÓ (1961) thought the species *Aphis nasturtii* Kalt. and *Aphis craccivora* Koch. to be the most significant. During investigations carried out between 1968 and 1970, of all the green-fly aphids it was *Aphis nasturtii* Kalt. followed by *Myzus persicae* Sulz. that showed the highest abundance values. *Aphis fabae* Scop., *A. gossypii* Glov., *Aulachortum solani* Kalt. and *Macrosiphum euphorbiae* Thom. occurred in negligible numbers. The aphids swarmed at the time when the seedlings were being planted out (KUROLI 1973). Of the *Auchenorrhyncha* group the species *Hyalesthes obsoletus* Sign., *Aphrodes bicinctus* Schrk., *Euscelis plebejus* Zett. and *Macrosteles laevis* Rib. were found throughout the vegetation period (KUROLI 1973). *Hyalesthes obsoletus* Sign. was mentioned by SZIRMAI (1956) as almost the only transmitter of the stolbur disease. According to observations by TÓTH (1968), *Gryllotalpa vulgaris* Leth., *Agrotis segetis* Hb., *Bibio hortulanus* L., *Bibio marci* L., *Melolonthidae larvae*, *Elateridae larvae*, *Tetranychus urticae* Koch., *Barathra brassicae* L., *Doralis fabae* Scop. and *Gryllus domesticus* L. are also found frequently on paprika plants. OBERMAYER (1951) includes *Gryllus desertus* Pall. among the animal pests. *Thrips* species *(Physopoda)* cause damage mainly under greenhouse conditions, but the larvae of *Agrostis segetus* Schiff. and *Phytometra gamma* L., which attack the foliage and the young fruit, are important pests (ANGELI 1968). In cases of long-lasting spring droughts *Agriotes sputator* L., *A. obscurus* L., *A. ustulatus* Schall. and *Lacon marinus* L. cause damage (KARDOS 1954). Paprika may also be damaged by *Ostrinia nubilalis* Hbn. (RYDER *et al.* 1969). According to observations made in 1975, the caterpillar of *Loxostege sticticalis* L. may be a dangerous chewing pest, devastating whole fields in the absence of adequate protection. Considering the population dynamics of aphids, *Coccinella septempunctata* L. and *Epistrophe balteata* DeG. were found to be the most important predators in 1958, while *Sphaerophoria scripta* L., *Syrphus lunulatus* Meig., *S. ribesii* L. and *Chrysotoxum intermedium* L. occurred in smaller numbers (SOLYMOSI—SZALAY-MARZSÓ 1959). *Aphidencyrtus aphidivorus* Mayr. and *Aphidius dauci* Marsch., as well as *Pachyneuron aphidis* Bché., *Coccinella septempunctata* L. and *Chilocorus* sp. are mentioned as parasites (SZALAY-MARZSÓ 1961). Ants, small insects and possibly bees are regarded as pollinators of red pepper plants, though self-pollination is considered to be predominant (OBERMAYER 1951). Other authors, on the other hand, think that paprika is a typically insect-pollinated plant; this is confirmed by its being a good melliferous plant (SZABÓ—GULYÁS 1973). Between 9 and 11 a.m. KORMOS (1948) regularly found bees on red pepper plants even in unfavourable weather. Besides *Apis mellifica* L., bumble-bees and other kinds of bees also visit red pepper flowers (MÁNDY 1963).

The area studied was a red pepper field of 23.6 ha in size at a distance of 7 km from Szeged. The soil was a carbonate meadow chernozem. The red pepper was planted in rows spaced at 60 cm from each other, with a plant distance of 60 cm (or less). Collecting was carried out in 1971—73, generally once a week in the morning hours, by grass-netting the plants one by one according to the "hundred plants" method (SZALAY-MARZSÓ 1969). On each occasion 5×20 plants were netted; the material collected was sorted after anaesthetization in ether. The data were processed in groups according to life forms (SZELÉNYI 1957). The tables only contain those species which were regular or characteristic members of the host plant community. For the data collected weekly the number of individual days pertaining to the first and second half of the current month ($N_1t_1, N_2t_2, \ldots, N_it_i$) is given (PETRUSEWICZ—MACFADYEN 1970). The number of individual days pertaining to an interval (t) can be determined by the aid of the formula $t\bar{N}$ where K is the number of collections and N_i the individual number of the population on each occasion.

$$\bar{N} = \frac{1}{K} \sum_{i=K}^{i=1} N_i$$

The individual day is in fact the number of "work-days" spent in the host plant community, which basically corresponds to the abundance, while the individual day dominance corresponds to the species dominance.

The intervals represented by the periods in the tables are: 1. 1st—15th June; 2. 16th—30th June; 3. 1st—15th July; 4. 16th—31st July; 5. 1st—15th August; 6. 16th—31st August; 7. 1st—15th September; 8. 16th—30th September; 9. 1st—15th October.

Mention must be made of the aerial spraying carried out on 6th July 1973. The composition of the spray was: 0.2% methyl-parathion (Wofatox Spritzpulver), 0.007% benomyl (NSZ 02), 31/Kh Wuxal foliage spray (9% N, 9% P_2O_5, 7% K_2O and trace elements), and 0.025% Citovett as wetting agent.

Among the corruptive elements (Tables 1—3) the *Empoasca* sp. population was dominant in all three years. The cool, rainy weather in 1972 was favourable for the aphids, so the dominance of cicada was then the lowest (39.74%). Spraying in 1973 mainly affected the aphids, which explains the 67.76% dominance of *Empoasca.*

The invasion of aphids began immediately after the host plant had been planted out. Initially quite a number of species took part in it, but only three of these (*Myzus persicae* Sulz., *Aphis craccivora* Koch, and *Aphis nasturtii* Kalt.) can be regarded as characteristic of the population. *Myzus persicae* Sulz. has the lowest temperature optimum (18—20 °C), which is why it was dominant in 1972; *Aphis nasturtii* Kalt. is the next in order, with a temperature

Table 1

Individual days and individual day

Species \ Period	1.		2.		3.		4.	
	$\overline{N}_1t_1$	d%	$\overline{N}_2t_2$	d%	$\overline{N}_3t_3$	d%	$\overline{N}_4t_4$	d%
Empoasca sp.	—	—	—	—	300	5.94	1,216	21.07
Empoasca sp. *larvae*	—	—	—	—	—	—	—	—
Myzus persicae Sulz.	105	18.91	150	23.07	477	9.44	336	5.82
Aphis nasturtii Kalt.	30	5.40	90	13.84	3,270	64.76	2,640	45.74
Aphis craccivora Koch.	—	—	45	6.92	374	7.40	693	12.00
Other *Aphididae*	210	37.83	5	0.76	164	3.24	203	3.51
Longitarsus pellucidus Fond.	135	24.32	180	27.69	182	3.60	261	4.52
Chaetocnema concinna Marsch.	30	5.40	60	9.23	109	2.15	48	0.83
Lygus rugulpiennis Popp.	45	8.10	45	6.92	35	0.69	112	1.92
Lygus sp. *larvae*	—	—	—	—	30	0.59	128	2.21
Tetranychidae	—	—	45	6.92	9	0.17	43	0.74
Haplothrips sp.	—	—	—	—	32	0.63	40	0.69
Other	—	—	30	4.61	67	1.30	51	0.86
Total	555	100	650	100	5,049	100	5,771	100

Table 2

Individual days and individual day

Species \ Period	3.		4.		5.	
	$\overline{N}_3t_3$	d%	$\overline{N}_4t_4$	d%	$\overline{N}_5t_5$	d%
Empoasca sp.	334	41.43	533	25.83	1,367	38.78
Empoasca sp. larvae	62	7.69	629	30.48	927	26.29
Myzus persicae Sulz.	—	—	10	0.48	296	8.39
Aphis nasturtii Kalt.	120	14.88	64	3.10	285	8.08
Aphis craccivora Koch.	—	—	—	—	8	0.22
Other *Aphididae*	—	—	—	—	35	0.99
Longitarsus pellucidus Fond.	51	6.32	64	3.10	50	1.41
Aphthona euphorbiae Schr.	26	3.22	200	10.08	12	0.34
Lygus rugulipennis Popp.	27	3.34	107	5.18	75	2.12
Lygus sp. larvae	117	14.51	240	11.63	143	4.05
Tetranychidae	26	3.22	80	3.87	249	7.06
Haplothrips sp.	11	1.36	—	—	27	0.76
Other *Cicadellidae*	16	1.98	32	1.55	27	0.76
Other	16	1.98	101	4.89	24	0.68
Total	806	100	2,063	100	3,525	100

dominance of corruptive elements in 1971

5.		6.		7.		8.		9.		1—9.	
$\overline{N}_5t_5$	d%	$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}_9t_9$	d%	$\overline{NT}$	d%
2,156	31.93	4,171	45.52	3,932	64.03	1,763	34.60	1,500	33.55	15,038	34.45
3,240	47.99	2,923	31.90	1,232	20.06	536	10.52	375	8.38	8,306	19.03
18	0.26	165	1.80	11	0.17	154	3.02	360	8.05	1,776	4.06
418	6.19	869	9.48	340	5.53	1,974	38.74	1,410	31.54	11,041	25.29
456	6.75	709	7.73	76	1.23	380	7.45	180	4.02	2,913	6.67
16	0.23	37	0.40	—	—	—	—	—	—	635	1.45
78	1.15	48	0.52	46	0.74	30	0.58	—	—	960	2.19
3	0.04	—	—	11	0.17	17	0.33	—	—	278	0.63
10	0.14	—	—	11	0.17	—	—	30	0.67	288	0.65
149	2.20	21	0.22	71	1.15	25	0.49	—	—	424	0.97
139	2.05	181	1.97	318	5.17	140	2.74	480	10.73	1,355	3.10
62	0.91	37	0.40	46	0.74	42	0.82	105	2.34	364	0.83
6	0.08	—	—	46	0.74	34	0.66	30	0.67	264	0.57
6,751	100	9,161	100	6,140	100	5,095	100	4,470	100	43,642	100

dominance of corruptive elements in 1972

6.		7.		8.		9.		3—9.	
$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}_9t_9$	d%	$\overline{NT}$	d%
2,144	35.73	2,599	20.24	2,033	23.11	1,782	30.56	10,792	27.07
1,572	26.20	1,013	7.89	679	7.72	169	2.89	5,051	12.67
624	10.40	5,082	39.58	3,994	45.41	1,847	31.68	11,853	29.73
560	9.33	3,415	26.60	1,643	18.68	1,230	21.09	7,317	18.35
—	—	42	0.32	—	—	16	0.27	66	0.16
16	0.26	35	0.27	11	0.12	98	1.68	195	0.48
64	1.06	16	0.12	11	0.12	16	0.27	272	0.68
—	—	—	—	—	—	16	0.27	262	0.65
15	0.25	66	0.51	15	0.70	177	3.03	482	1.20
105	1.75	79	0.61	120	1.36	53	0.90	857	2.14
675	11.25	213	1.65	173	1.96	197	3.37	1,613	4.04
160	2.66	45	0.35	45	0.51	—	—	288	0.72
48	0.80	141	1.09	49	0.55	183	3.13	496	1.24
16	0.26	92	0.71	22	0.24	46	0.70	317	0.79
5,999	100	12,838	100	8,795	100	5,830	100	39,861	100

Table 3

Individual days and individual day

Period / Species	1.		2.		3.	
	$\overline{N}_1t_1$	d%	$\overline{N}_2t_2$	d%	$\overline{N}_3t_3$	d%
Empoasca sp.	—	—	375	9.74	303	37.47
Empoasca sp. larvae	—	—	—	—	23	2.25
Aphididae	633	43.32	2,933	76.24	469	45.09
Longitarsus pellucidus Fond.	94	6.43	27	0.70	18	1.76
Lygus rugulipennis Popp.	60	4.10	206	5.35	62	6.06
Lygus sp. larvae	—	—	—	—	—	—
Haplothrips sp.	35	2.39	121	3.14	—	—
Acariformes	556	38.05	121	3.14	22	2.15
Other *Cicadellidae*	—	—	64	1.66	35	3.42
Other	83	5.67	—	—	9	0.86
Total	1,461	100	3,847	100	1,021	100

Table 4

Individual days and individual day

Period / Species	1.		2.		3.		4.	
	$\overline{N}_1t_1$	d%	$\overline{N}_2t_2$	d%	$\overline{N}_3t_3$	d%	$\overline{N}_4t_4$	d%
Aeolothrips intermedius Bagn.	—	—	—	—	204	26.56	1,928	63.71
Ae. intermedius Bagn. larvae	—	—	—	—	15	1.95	24	0.79
Orius niger Wolff.	—	—	—	—	59	7.68	320	10.57
Orius majusculus Rent.	—	—	—	—	—	—	112	3.70
Orius spp. larvae	—	—	—	—	—	—	16	0.52
Nabis feroides Rem.	—	—	—	—	91	11.84	128	4.23
N. feroides Rem. larvae	—	—	—	—	—	—	—	—
Coccinella septempunctata L.	—	—	—	—	104	13.54	48	1.58
Adonia variegata Goeze.	—	—	—	—	27	3.51	112	3.70
Chrysopa spp.	—	—	—	—	11	1.43	32	1.05
Araneidea	105	100	90	100	191	24.86	192	6.34
Macrocentrus collaris L.	—	—	—	—	—	—	7	0.23
Litomastix truncatellus Fall.	—	—	—	—	45	5.85	64	2.11
Charips spp.	—	—	—	—	5	0.65	—	—
Telenomus spp.	—	—	—	—	—	—	—	—
Diglyphus isaca Walk.	—	—	—	—	5	0.65	5	0.16
Aphelinus hordei Kurd.	—	—	—	—	—	—	5	0.16
Inostemma contariniae Szel.	—	—	—	—	11	1.43	32	1.05
Total	105	100	90	100	768	100	3,026	100

dominance of corruptive elements in 1973

4.		5.		6.		7.		8.		1—8.	
$\overline{N}_4t_4$	d%	$\overline{N}_5t_5$	d%	$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}T$	d%
1,499	35.20	1,350	45.60	4,185	56.95	4,250	57.27	4,360	66.46	16,382	47.09
1,222	29.40	1,029	34.82	1,997	27.17	2,120	28.57	800	12.13	7,191	20.67
200	6.94	94	3.10	195	2.65	537	7.23	975	14.79	6,124	17.60
131	3.16	43	1.45	54	0.73	51	0.60	30	0.45	440	1.20
134	3.23	39	1.31	24	0.32	24	0.32	105	1.59	654	1.00
262	6.32	99	3.35	106	1.44	—	—	—	—	467	1.34
246	5.93	47	1.59	198	2.69	180	2.42	180	2.73	1,007	2.89
333	0.03	170	5.75	454	6.17	87	1.17	75	1.13	1,818	5.22
42	1.01	84	2.84	135	1.83	129	1.73	45	0.68	534	1.53
27	0.65	—	—	—	—	42	0.56	—	—	161	C.46
4,144	100	2,955	100	7,348	100	7,420	100	6,590	100	34,786	100

dominance of obstant elements in 1971

5.		6.		7.		8.		9.		1—9.	
$\overline{N}_5t_5$	d%	$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}_9t_9$	d%	$\overline{N}T$	d%
2,982	52.02	3,541	62.69	1,539	28.06	293	9.73	15	0.80	10,503	40.83
390	6.80	363	6.42	2,224	40.55	1,375	45.66	180	9.70	4,571	17.77
559	9.75	283	5.01	368	6.71	135	4.48	90	4.85	1,814	7.05
150	2.61	37	0.65	30	0.54	17	0.56	—	—	346	1.34
960	16.74	421	7.45	533	9.71	580	19.26	225	12.12	2,735	10.63
100	1.74	144	2.54	81	1.47	68	2.25	300	16.17	912	3.54
25	0.43	43	0.76	—	—	38	1.26	—	—	106	0.41
—	—	—	—	—	—	32	1.06	160	8.62	344	1.33
189	3.29	224	3.96	182	3.31	70	2.32	225	12.12	1,029	4.00
—	—	11	0.19	—	—	—	—	—	—	54	0.20
326	5.68	453	8.02	425	7.74	314	10.42	660	35.57	2,756	10.71
6	0.10	5	0.08	10	0.18	—	—	—	—	28	0.10
7	0.12	5	0.08	—	—	—	—	—	—	121	0.47
13	0.22	11	0.19	30	0.54	30	0.99	—	—	89	0.34
—	—	91	1.61	51	0.92	17	0.56	—	—	159	0.61
6	0.10	11	0.19	11	0.20	—	—	—	—	38	0.14
19	0.33	5	0.08	—	—	42	1.39	—	—	71	0.27
—	—	—	—	—	—	—	—	—	—	43	0.16
5,732	100	5,648	100	5,484	100	3,011	100	1,855	100	25,719	100

Table 5

Individual days and individual day

Species \ Period	3.		4.		5.	
	$\overline{N}_3t_3$	d%	$\overline{N}_4t_4$	d%	$\overline{N}_5t_5$	d%
Aeolothrips intermedius Bagn.	1,020	39.62	1,360	33.60	2,307	34.32
Ae. intermedius Bagn. larvae	364	14.14	837	20.68	1,956	29.10
Orius spp.	324	12.58	314	7.75	647	9.62
Orius spp. larvae	91	3.53	539	13.31	754	11.21
Nabis feroides Rem.	56	2.17	117	2.89	72	1.07
N. feroides Rem. larvae	—	—	—	—	77	1.14
Coccinella septempunctata L.	5	0.19	27	0.66	54	0.80
Hyppodamia 13-punctata L.	—	—	—	—	42	0.62
Halyzia 14-punctata L.	27	1.04	32	0.79	27	0.40
Adonia variegata Goeze.	350	13.59	347	8.57	249	3.70
Coccinellidae larvae	—	—	—	—	—	—
Chrysopa spp.	46	1.78	133	3.28	60	0.89
Araneidea	150	5.82	272	6.72	249	3.70
Telenomus sp.	—	—	37	0.91	152	2.24
Diglyphus isaca Walk.	35	1.35	32	0.79	12	0.17
Euplectrus bicolor Swed.	—	—	—	—	—	—
Macrocentrus collaris L.	—	—	—	—	15	0.22
Pachyneuron concolor Först.	20	0.77	—	—	—	—
Litomastix truncatellus Fall.	86	3.34	—	—	—	—
Tetrastichus galactropus	—	—	—	—	—	—
Diapriidae	—	—	—	—	24	0.35
Mymaridae	—	—	—	—	12	0.17
Charips sp.	—	—	—	—	12	0.17
Total	2,574	100	4,047	100	6,721	100

optimum of 20—22 °C, which explains its dominance in 1971, while *Aphis craccivora* Koch. was an order of magnitude behind.

The group "other Auchenorrhyncha" includes *Laodelphax striatella* Fall., *Agallia laevis* Rib., *Macrosteles laevis* Rib. and *Psamotettix alienus* Dahlb.

Moths mentioned as pests in the literature were found in negligible numbers, and mainly in July and August 1972.

Of the obstant elements (Tables 4—6) *Aeolothrips intermedius* Bagn., a species feeding on mites and insects with soft teguments, was dominant each year. This species, which prefers hot dry weather, develops two generations on red pepper plants. Of the two species of *Anthocoridae*, *Orius niger* Wolff. was dominant; the proportion of *Orius majusculus* Rent. was 22% in 1971, 11.3% in 1972 and negligible in 1973. *Nabis feroides* Rem. was also a constant carnivore present in the stand. Besides *Coccinella septempunctata* L., a member of the *Coccinellidae* *dominance of obstant elements in 1972*

6.		7.		8.		9.		3—9.	
$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}_9t_9$	d%	$\overline{N}T$	d%
1,408	37.92	211	11.56	15	0.73	—	—	6,321	28.16
480	12.92	258	14.14	105	5.15	71	4.65	4,071	18.14
240	6.46	101	5.53	210	10.31	105	6.88	1,941	8.65
384	10.34	260	14.25	240	11.78	120	7.87	2,388	10.64
96	2.58	171	9.37	150	7.36	105	6.88	767	3.41
80	2.15	43	2.35	60	2.94	60	3.93	320	1.42
16	0.43	63	3.45	80	3.92	30	1.96	275	1.22
16	0.43	11	0.60	—	—	8	0.52	77	0.34
48	1.29	33	1.80	60	2.94	30	1.96	257	1.14
64	1.72	—	—	45	2.21	15	0.98	1,070	4.76
—	—	6	0.32	180	8.84	105	6.88	291	1.29
30	0.80	15	0.82	—	—	—	—	284	1.26
435	11.71	509	27.90	525	25.78	570	37.40	2,710	12.07
256	6.89	40	2.19	—	—	—	—	485	2.16
32	0.86	25	1.37	171	8.39	135	8.85	442	1.96
—	—	28	1.53	30	1.47	—	—	58	0.25
—	—	—	—	45	2.21	—	—	60	0.26
—	—	3	0.16	27	1.32	—	—	50	0.25
16	0.43	18	0.98	12	0.58	5	0.32	137	0.61
16	0.43	18	0.98	42	2.06	—	—	76	0.33
32	0.86	—	—	39	1.91	60	3.93	155	0.69
32	0.86	11	0.60	—	—	45	2.95	100	0.44
32	0.86	—	—	—	—	60	3.93	104	0.46
3,713	100	1,824	100	2,036	100	1,524	100	22,439	100

family also mentioned in the literature, *Adonia variegata* Goeze. is the other characteristic species. *Chrysopa* species and representatives of the family *Syrphidae* only occurred in considerable numbers in 1972, a year which was cooler and rainier than the other two. The order *Araneidea* was represented to about 80% by *Tibellus oblongus*, a species of the *Thomisidae* family.

The ichneumonids collected are, in fact, all imagos, i.e. they belong to the sustinent elements; yet their very occurrence means that they probably lived as larvae in the same biocenosis. Besides those shown in the table, the number of species represented by only a few specimens amounted to 32 in 1971, 120 in 1972 and 20 in 1973, but these cannot be considered as characteristic.

The sustinent elements were only identified qualitatively rather than quantitatively, so data on these are not presented in a separate table. In 1971 two *Hymenoptera* species

Table 6

Individual days and individual day

Species \ Period	1.		2.		3.	
	$\overline{N}_1t_1$	d%	$\overline{N}_2t_2$	d%	$\overline{N}_3t_3$	d%
Aeolothrips intermedius Bagn.	—	—	255	24.28	83	14.04
Ae. intermedius Bagn. larvae	—	—	—	—	8	1.55
Orius spp.	30	28.03	30	2.85	45	7.61
Orius spp. larvae	—	—	—	—	8	1.35
Nabis feroides Rem.	—	—	135	12.85	135	22.84
N. feroides Rem. larvae	45	42.05	—	—	—	—
Coccinella septempunctata L.	—	—	45	4.28	49	8.29
Adonia variegata Goeze.	—	—	—	—	3	0.50
Halyzia 14-punctata L.	—	—	—	—	31	5.24
Coccinellidae larvae	28	26.16	375	35.71	45	7.61
Chrysopa spp.	—	—	60	5.71	62	10.49
Araneidea	—	—	75	7.14	93	15.73
Macrocentrus collaris L.	—	—	12	1.14	12	2.03
Meteorus laeviventris	—	—	—	—	—	—
Mymaridae spp.	—	—	—	—	—	—
Diglyphus isaca Walk.	—	—	—	—	2	0.33
Charips sp.	—	—	—	—	—	—
Telenomus sp.	4	3.73	63	6.00	15	2.53
Litomastix truncatellus Fall.	—	—	—	—	—	—
Total	107	100	1,050	100	591	100

Apis mellifica L. (68%) and *Andrena flavipes* Panz. (26%), were important. The former was found from the beginning of July up to the end of the vegetation period, while the latter only occurred in July. Besides these, some *Halictus species* (*H. malachurus* K., *H. interruptus* Pz., *H. quadricinctus* F., *H. eurygnathus* Blüthg.) took part in the process of pollination. Among the *Diptera* only the *Syrphidae* are worth mentioning, from August onwards. Their species were: *Lathyrophthalmus aeneus* Scop., *Eristalomyia tenax* L., *Syrphus corolae* F. and *Epistrophe balteata* Deg.

In 1972 the *Hymenoptera*, though they were fewer in number than in the previous year, were joined by a few *Polistes gallicus* L. The number of *Diptera*, on the other hand, was the largest that year. Besides the dominant species *Epistrophe balteata* DeG. (42%), many *Sphaerophoria scripta* L. (19%) and somewhat fewer *Syrphus corolae* F. and *Lathyrophthalmus aeneus* Scop. were found. The decisive factor in their appearance was not the intensity of flowering but the quantity of aphids consumed by the larvae.

In 1973 only a few *Syrphidae* and *Aphis mellifica* L. were active. It can thus be established as a fact, that red pepper, though a good honey-bearing plant, does not have a rich sustinent community.

dominance of obstant elements in 1973

4.		5.		6.		7.		8.		1—8.	
$\overline{N}_4t_4$	d%	$\overline{N}_5t_5$	d%	$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}T$	d%
4,560	56.04	3,210	54.89	1,366	32.91	90	3.07	30	1.98	9,594	34.44
802	9.85	750	12.82	774	18.65	711	24.29	105	6.94	3,150	12.95
725	8.90	585	10.00	256	6.16	405	13.84	150	9.92	2,226	9.15
738	9.06	510	8.72	960	23.13	615	21.01	180	11.90	3,011	12.38
245	3.01	90	1.53	58	1.39	270	9.22	450	29.76	1,383	5.68
208	2.55	90	1.53	115	2.77	105	3.58	—	—	563	2.31
16	0.19	—	—	48	1.15	75	2.56	105	6.94	338	1.38
85	1.04	105	1.79	8	0.19	60	2.05	30	1.98	291	1.19
—	—	—	—	8	0.19	30	1.02	45	2.97	114	0.46
5	0.06	—	—	—	—	30	1.02	—	—	483	1.98
53	0.65	—	—	5	0.12	—	—	—	—	180	0.74
293	3.60	240	4.10	298	7.18	330	11.27	360	23.80	1,689	6.94
94	1.15	30	0.51	13	0.31	10	0.34	—	—	171	0.70
38	0.46	23	0.39	—	—	—	—	30	1.98	91	0.37
176	2.16	60	1.02	93	2.24	60	2.05	—	—	389	1.59
62	0.76	60	1.02	26	0.62	15	0.51	12	0.79	177	0.72
—	—	15	0.25	26	0.62	30	1.02	—	—	71	0.29
37	0.45	35	0.59	32	0.77	75	2.56	—	—	261	1.07
—	—	45	0.76	64	1.54	15	0.51	15	0.99	139	0.57
8,137	100	5,848	100	4,150	100	2,926	100	1,512	100	24,321	100

The intercalary elements (Table 7) are presented only for the sake of completeness. *Lasius alienus* Först. fed mainly on honey-dew, which is why it was included. Its individual density is closely related with the infestation by aphids; in addition, it is more frequent in hot, dry weather.

The *Collembolae* are dependent on the presence of plant material, so they increase in number considerably at the end of the vegetation period, though their individual density above the soil is always higher in rainy weather. This was the case in 1972, when some of the crop began to rot because of frequent rainfall.

Three aspects of the host plant community, spring, summer and late summer, can be distinguished. The first aspect lasts from planting out until July, the second is in July and August, and the third in September and October. Some 10% of the total activity of the host plant cenosis occurs during the spring aspect, about 70% during the summer aspect and 20% during the late-summer aspect (Fig. 1).

Spring aspect: The first aphids appear at the time when the seedlings are planted out, in the middle of May, and are found throughout the vegetation period depending on the weather. Mites and Elateridae imagos occur simultaneously with them. The latter are followed about

Table 7

Individual days and individual day dominance

Species \ Period	1. $\overline{N}_1t_1$	1. d%	2. $\overline{N}_2t_2$	2. d%	3. $\overline{N}_3t_3$	3. d%	4. $\overline{N}_4t_4$	4. d%
								1971
Lasius alienus Först.	225	100	450	100	1,171	100	720	100
Collembola	—	—	—	—	—	—	—	—
Total	225	100	450	100	1,171	100	720	100
								1972
Lasius alienus Först.					540	87.80	123	31.61
Collembola					—	—	60	15.42
Anthicus antherinus L.					75	12.20	30	7.71
Lathrididae					—	—	80	20.56
Olibrus sp.					—	—	96	24.67
Total					615	100	389	100
								1973
Lasius alienus Först.	—	—	—	—	8	47.05	160	69.56
Collembola	—	—	—	—	—	—	—	—
Anthicus antherinus L.	—	—	—	—	8	47.05	45	19.56
Olibrus sp.	—	—	—	—	—	—	4	1.73
Lathrididae	—	—	—	—	1	5.90	21	9.13
Total	—	—	—	—	17	100	230	100

a week later by *Coccinella septempunctata* L., depending on the individual density of *Myzus persicae* Sulz, then towards the end of May the aphids are accompanied by *Lasius alienus* Först. and *Adonia variegata* Goeze. *Longitarsus pellucidus* Fond. and *Lygus rugulipennis* Popp. appear at the beginning of June. From the middle of June the spiders, *Orius niger* Wolff. and *O. majusculus* Rent., increase in numbers depending on the mites and aphids. At the end of the spring aspect the *Elateridae* species leave the community.

Summer aspect: During this period the development stage of the plant and the intensity of flowering provide favourable conditions for the multiplication of the following species.

At the end of June and the beginning of July *Nabis feroides* Rem. appears and lays its eggs in the flowers. It is at this stage that one of the most important corruptive elements, *Empoasca* sp., puts in an appearance, together with *Aeolothrips intermedius* Bagn. and *Haplothrips* sp. The flowers attract the sustinent elements, particularly *Apis mellifica* L. and *Andrena flavipes* Panz. While the latter leaves the biocenosis at the end of July, domestic honeybees *of intercalary elements in 1971—1973*

5.		6.		7.		8.		9.		1—9.	
$\overline{N}_5t_5$	d%	$\overline{N}_6t_6$	d%	$\overline{N}_7t_7$	d%	$\overline{N}_8t_8$	d%	$\overline{N}_9t_9$	d%	$\overline{N}T$	d%
293	100	704	100	220	78.57	248	76.78	105	38.88	4,136	93.23
—	—	—	—	60	21.43	75	23.22	165	61.12	300	6.77
293	100	704	100	280	100	323	100	270	100	4,436	100
205	52.16	180	60.20	66	3.51	—	—	—	—	1,114	10.65
60	15.26	80	26.75	1,735	92.48	2,730	98.23	3,921	95.61	8,386	82.14
15	3.81	—	—	—	—	—	—	—	—	120	1.15
71	18.06	16	5.35	15	0.79	49	1.77	142	3.46	373	3.56
42	10.68	23	7.69	60	3.19	—	—	38	0.92	259	2.47
393	100	299	100	1,876	100	2,779	100	4,101	100	10,452	100
175	64.33	—	—	15	4.28	—	—			358	25.55
—	—	—	—	270	77.14	75	15.15			345	24.62
75	27.57	—	—	2	0.57	—	—			130	9.27
8	2.94	13	35.13	39	11.14	180	36.36			244	17.41
14	5.14	24	64.87	24	6.85	240	48.48			324	23.12
272	100	37	100	350	100	495	100			1,401	100

can be found up to the end of the vegetation period. *Olibrus* sp., members of the *Lathrididae* family and the *Telenomus* sp. appear in the middle of July. *Chaetocnema concinna* Marsh. stays in the paprika field for 2—3 weeks from the end of July. It is then that caterpillars, particularly *Phytometra gamma* L. and *Agrostis segetum* Schiff., spread all over the field.

At the beginning of August a large proportion of the sustinent elements is made up of *Syrphidae*. *Euplectus bicolor* Swed. and *Litomastix truncatellus* Balm. occur from the middle of the month. Aphids, together with *Lasius alienus* Först., are found in this aspect as well. *Aeolothrips intermedius* Bagn., *Telenomus* sp., *Lygus rugulipennis* Popp. and *Haplothrips* sp. are encountered in the largest individual numbers in the middle of August. By the end of this month *Araneidae* and *Empoasca* sp. reach a maximum.

Late summer aspect: By this time the intensity of flowering has lessened and the reproduction of the insects developing in the flowers has slowed down; they leave the host plant community one after the other, or are found only as imagos. The intercalary elements,

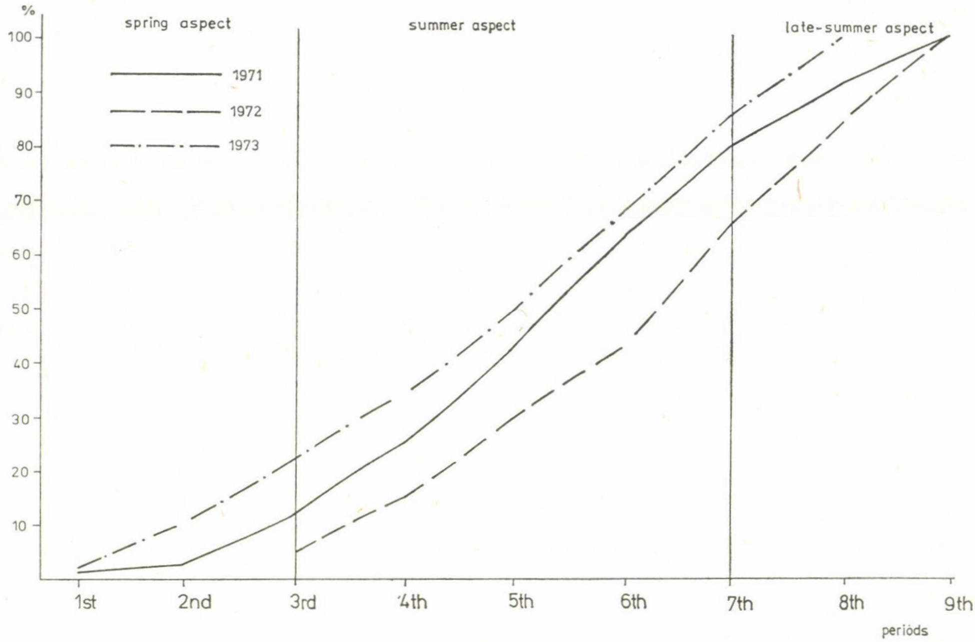

Fig. 1. Percentage changes in individual days spent in the host plant community by its members during the three aspects. (Spring aspect = from planting out totle middle of July; Summer aspect = from mid-July to mid-September; Late-summer aspect = from mid-September to the end of the vegetation period; Period = the periods listed in the text)

primarily the *Collembolae*, increase in numbers. *Haplothrips* sp. and *Aeolothrips intermedius* Bagn. disappear by the beginning of September. On the other hand, *Syrphidae larvae* and *Pachyneuron concolor* Först. may become numerous, depending on the aphids and on the weather. Aphids, together with *Lasius alienus* Först., *Coccinella septempunctata* L., *Adonia variegata* Goeze., *Nabis feroides* Rem. and *Orius niger* Wolff. can be found up to the end of the vegetation period. Other members of the community which remain until the end are *Empoasca* sp., *Olibrus* sp., *Lathrididae*, *Lygus rugulipennis* Popp., *Acariformes*, *Araneidea* and *Apis mellifica* L.

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CONTRIBUTION TO THE RUBUS FLORA OF BARANYA COUNTY

The *Rubus* species are important from several points of view, so investigations on this subject may well lead not only to botanical results but may also be of economic use.

These species are very attractive in appearance; some foreign species, particularly from Asia, e.g. *R. henryi* Hemsl. or *R. phoenicolasius* Maxim., are also known as ornamental plants. In a similar way some Hungarian forms (e.g. of the species *R. candicans* Wh.) would also be suitable for use in ornamental gardens, but their chief use is for their tasty fruit, which have a high vitamin C content.

The leaves of *Rubus* species cannot be left out of consideration either; they provide raw material for medicinal and other teas. The leaves contain tannin, organic acids, aromatic substances, vitamin C, etc. An infusion of the leaves is used against diabetes, bladder complaints and diarrhoea. The leafy shoots of some species can also be used for the preparation of hair-dyes (blackening).

Owing to their abundant leaves, which often overwinter, they may be important as emergency winter feed for herbivorous animals in wildlife management.

As one of the first plants to become established in clearings, *Rubus* species may be useful in preventing soil erosion. However, *Rubus* species may also cause damage in forestry and agriculture by suppressing more useful plant species (e.g. in nurseries and young plantations, etc.).

Prior to giving a detailed description, mention should be made of those Hungarian botanists who contributed to a knowledge of the Hungarian *Rubus* flora: Borbás, Budai, Gáyer, Jávorka, Kiss, Soó and Vöröss.

The investigations made so far have mainly been confined to the Mecsek hills in the neighbourhood of Pécs, and particularly to the ski-run. This area is rather complex from an ecological and coenological point of view, so the *Rubus* flora is also diversified. The species found there are:

subgenus: **Idaeobatus** Focke

1. *R. idaeus* L. f. inermis Hayne

subgenus: **Eubatus** Focke

section: **Caesii** (Triviales Müll.)

2. *R. caesius* L.

section: **Moriferi**

subsection: *Discolores* Müll.

3. *R. procerus* Müll. ssp. *lacertosus* Sudre f. hamulosus Sudre
4. *R. candicans* Wh.
— *R. c.* ssp. *neomalacus* (Sudre) Soó
— *R. c.* ssp. *thyrsanthus* (Focke) Gáy. f. *hylophilus* (Rip.)
5. *R. arduennensis* Libert in Lej.
— *R. a.* ssp. *collicolus* Sudre

subsection: *Hystrices* Focke

6. *R. obtruncatus* Müll.

subsection: *Glandulosi* Müll.

7. *R. tereticaulis* Müll.
— *R. t.* ssp. *saxetanus* Sudre
8. *R. scaber* Wh. et N.
9. *R. schleicheri* Wh. in Boenn.
10. *R. bellardii* Wh. et N.
11. *R. rivularis* Müll. et Wirtg.
12. *R. serpens* Wh. ssp. *chlorostachys* (Müll.) Sudre var. *mitigatus* (Müll.) Sudre

Hybrids:

13. *R.* × *virgultorum* Müll. *(R. caesius* × *candicans)*
14. *R.* × *orthacanthus* Wimmer *(R. caesius* × *schleicheri)*
15. *R. caesius* × *bellardii*

The occurrence of *R. idaeus* in the Mecsek is considered questionable by Soó (1966), Horvát (1942) only has reliable data on it from more than a hundred years ago. In the course of our present investigations, plants confirming the occurrence of this species in the Mecsek have again been found on the ski-run.

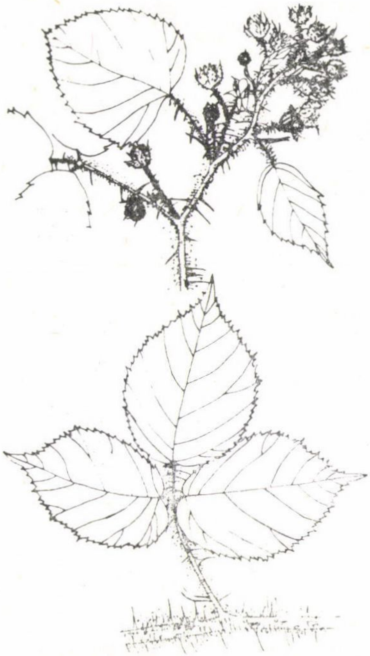

Fig. 1. Inflorescence and leaf of young shoot in *Rubus obtruncatus* Müll. (original)

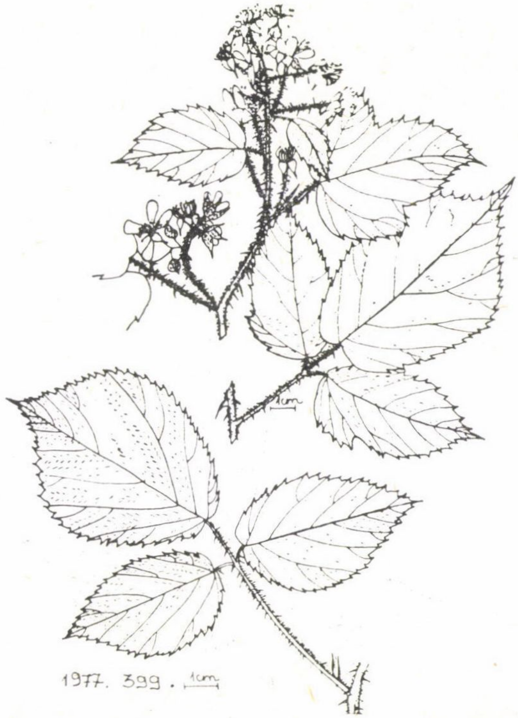

Fig. 2. Inflorescence, lower leaf of flowering shoot, and leaf of young shoot in *Rubus scaber* Wh. et N. (original)

With the exception of *R. caesius* and *R. candicans* all further data for the Mecsek are new:

The basic form of *R. procerus*, which was not found along the ski-run, is reported in the Mecsek by Horvát (1975); its subspecies lacertosus from the Villányi hills is mentioned in the same work. There is no data on the occurrence of this subspecies in the Mecsek, and the nearest literary data on f. *hamulosus* is from Veszprém. They differ from the basic form in the highly curved thorns and the leafy inflorescence; the petals are pink.

R. candicans is a common species in the Mecsek; its subspecies are not mentioned. The ssp. *neomalacus* has dark red young shoots and pink petals: the terminal leaflets of ssp. *thyrsanthus* f. *hylophylus* are large, broadly oval and pointed at the tip, the inflorescence is leafy; a distinctive feature of the ssp. *constrictus* is the green lower leaf surface.

R. arduennensis, which at first sight is difficult to distinguish from the forms of *R. candicans*, is found in large masses. Important characteristics of *R. arduennensis* are the longer petiole and wedge-like shoulder of the terminal leaflet.

R. obtruncatus (Fig. 1) is characterized by long fine thorns and long reddish glands. The inflorescence is spiky and glandular, and the petals are pink. Because of the shape and length of the thorns it can be mistaken for *R. vestitus* ssp. *vestitus*, though it differs from the latter in the colour of the young shoot, which is not red, and by the shape and edge of the leaflets.

R. tereticaulis and its subspecies *saxetanus* also occur in large masses. The leaflets of the usually trefoil leaves are rhombic, or less frequently egg-shaped, with elongated points;

Fig. 3. Inflorescence and leaf of young shoot in *Rubus rivularis* Müll. et Wirtg. (original)

Fig. 4. Inflorescence of *Rubus caesius* × *bellardii* (original)

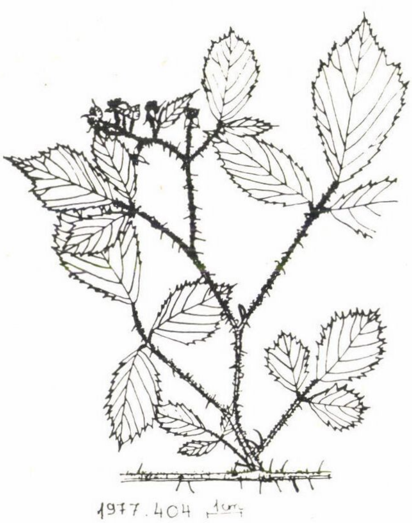

Fig. 5. Part of young shoot in *Rubus caesius* × *bellardii* (original)

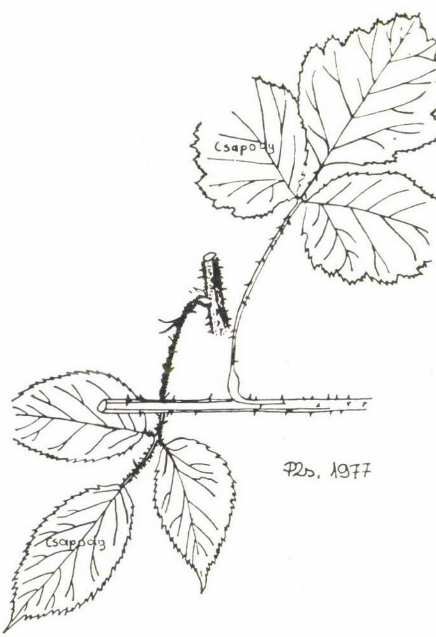

Fig. 6. Leaf of *Rubus caesius* L. (above); leaf of *R. bellardii* Wh. et N. (below) (after V. Csapody)

the glands of the young shoots and the inflorescence are short. The subspecies *saxetanus* is less glandular and has finer thorns and delicately dentate leaflets. The terminal leaflet has a short petiole and is obovate. It sometimes differs from the taxonomic description in the occurrence of quintuple leaves.

The young shoots of *R. scaber* (Fig. 2) bend downwards, and the terminal leaflets are obovate.

R. schleicheri specimens with weak thorns also differ from the description, but this difference seems to be admissible within the species.

R. rivularis (Fig. 3) has leaves with hairy upper surfaces.

No reference is made to the hybrid *R. caesius* × *bellardii* (Figs 4—6) in the available taxonomic descriptions and identification manuals. This circumstance made the identification uncertain. Some leaves are characteristic of *caesius* and others of *bellardii*, while the third type is a transition between the two.

At other sites in Baranya county the following *Rubus* species have been found:

Pécs, Tettye, Pintér garden:

16. *R.* × *spinosissimus* Müll. [*R. caesius* × *serpens* ssp. *serpens* var. ***longisepalus*** (Müll.) Sudre]

Pécs, Havihegy:

— *R. candicans* Wh.

— *R. c.* ssp. *candicans* f. *coarctatus* (Müll.) Sudre

17. *R.* × *semiarduennensis* Sudre *(R. caesius* × *arduennensis)*

Orfű, clearing:

— *R.* × *orthacantus* Wimmer *(R. caesius* × *schleicheri)*

Apart from other problems involved in collecting and identification, much trouble is caused by the fact that the characteristics described in identification manuals often require subjective judgements (e.g. hairiness, thorniness, etc.). A taxonomic key based on only one or two properties often causes errors. Differentiating characters are, for example, the length of the glands or the colour of the petals, which are properties which may later appear in the forms of a *Rubus* group whose basic forms are different. In the course of identification the characters of the basic form are followed, so this often makes the work difficult. Taxonomic keys should be extended to include infraspecific taxa, together with their differential characters, in the main line of the taxonomic key. In the experience of the authors, the use of a taxonomic key with only a text is seldom sufficient in microtaxonomic studies on *Rubus* species. It must be completed with at least true-to-life drawings, showing every important detail. The microtaxonomic system of such a complex, problematic group of plants cannot be precisely and reliably constructed on a purely morphological basis. Further biochemical, genetic, physiological, ecological and coenological studies are also necessary.

The evidentiary specimens of the Rubus taxa mentioned above can be found in the herbarium of Gábor Lantos and Zsuzsa Petrovics (address: Romonya, Rákóczi u. 11.).

Acknowledgement

For the purpose of comparison the Rubus material from the herbarium of the Teachers Training College, Pécs was used in this work. In obtaining the results described above a great

deal of help was received from A. O. Horvát and L. Zs. Vöröss, who are sincerely thanked for their kind collaboration.

*

Prepared at the Botanical Department of the Teachers Training College, Pécs.

Zs. Petrovics

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IDENTIFICATION AND SPECIFIC REACTIONS OF ALKALI STABLE AMINO ACID PHOSPHATES IN MYOSIN HYDROLYSATES

As described in an earlier work (Fazekas *et al.* 1976a, b) nearly 4 mol of the 10–12 mol phosphate found in the alkaline hydrolysate of myosin from the skeletal muscle of rabbit (chinchilla) is histidine phosphate (P-His). Owing to the cautious 3-hour partial hydrolysis a considerable proportion of the phosphates in the hydrolysate is found in the form of longer or shorter peptides, so the total P-content, particularly the chemical nature of the peptide phosphates, cannot be clarified. To determine the nature of the chemical bond of the total P-content is now an urgent task, since it has been demonstrated that the P-content of freshly isolated "preparative myosin" can be increased by phosphorylation (Fazekas *et al.* 1979). Priority has now been given to this problem in order to determine the chemical nature of newly incorporated P.

Since the preparation and purification of enzymatic P-peptides is a lengthy procedure and the subsequent sequential process is slow, chemical methods were chosen. By prolonging the hydrolysis and moderately increasing the temperature an attempt was made to release the total amino acid phosphates of myosin and separate them by ion-exchange chromatography. By eluting the synthetic amino acid phosphates both separately and together, it was hoped to determine the elution profile for the individual amino acid phosphates, and to identify the P and amino acid content fractions obtained from the hydrolysate chemically, on the basis of specific reactions.

Of the synthetic amino acid phosphates, the P-Arg was purchased commercially (Calbiochem, AG Switzerland) and synthesized by the technique of Marcus–Morrison (1964), while the N^{ε}-P-Lys was synthesized according to the method of Zetterquist–Engström (1967). N^{π}-P-His and N^{τ}-P-His were synthetized by the method of Hultquist *et al.* (1966) and Hultquist (1968). By choosing suitable concentrations of the initial materials it was possible to achieve oriented synthesis (Fazekas *et al.* 1976b).

Myosin was prepared from the *m. long. dorsi* of rabbit (chinchilla); the purification has been described in detail in an earlier paper (Fazekas *et al.* 1979). Only the pyrophosphate was omitted, so that only the extraction solution contained phosphate, as a buffer. The preparations were subjected to chromatography on a DEAE-cellulose column, or to gel-filtration on a Sepharose 4 B (CL-4B) column. The tubes containing myosin were collected and the myosin was precipitated by adding 2/3 of its volume of acetone. The myosin was then freed from lipids using a mixture of Chl : MeOH (2 : 1 v/v). The amino acid phosphates were gained from the dried salt-free specimens by means of 3 mol KOH hydrolysis (at 105° C for 10—23 hours) in "Pyrex" borosilicate glass ampules (which are always filled with concentrated KOH during storage). As a consequence of the prolonged hydrolysis a precipitate containing Si appeared in the hydrolysate. This increased during storage (in open tubes owing to CO_2 adsorption) and separated almost quantitatively when CO_2 was introduced. The precipitate was removed in a centrifuge (at 5000 g, 10 min).

Since the walls of the ampules dissolved it was necessary to carry out a blank hydrolysis, using 3 mol KOH but no protein, and a parallel chromatographic separation to check the quantity of Si dissolved and its disturbing effect on the molybdate reaction. The amount of Si dissolved from "Pyrex" tubes used for the first time is considerable, but from those used several times hardly any silicate is dissolved. After the dissolution of Si has reached equilibrium the amount of Si dissolved from the walls of the ampule is always the same, so the background effect can be checked and easily eliminated.

Hydrolysates containing amino acid phosphates were diluted to a concentration of 0.01—0.02 mol KOH before being applied to the equilibrated Dowex I X-8 (0.9×12 cm) column. The total P content of the hydrolysate was bound by the Dowex ion-exchange resin in the column. The column was washed with 0.01 mol $KHCO_3$ until UV absorption at 225 nm or a positive ninhydrin reaction was hardly perceptible. Then a 160 ml mixing chamber was filled with 0.02 mol $KHCO_3$, and the reservoir with 0.2 mol $KHCO_3$, and stepwise linear gradient elution was performed. P-Arg (and its hydrolytic phosphorylated products) were eluted before Pi at $KHCO_3$ concentrations of between 0.06 and 0.08 mol, while P-Lys was eluted immediately after Pi. In the presence of large quantities of Pi the P-Lys may be indistinguishable from the Pi peak. Both P-His fractions were eluted at a much higher $KHCO_3$ concentration and were well separated from each other. The $KHCO_3$ solution in the reservoir was changed several times for a solution with a higher concentration (indicated by arrows in the figures), so the collection of a large number of P-free tubes was avoided.

The P content was determined by the method of Fiske—Subbarow (1925), except that the ammonium P-molybdate derivative was reduced with ascorbic acid to molybdenum blue (Lowry *et al.* 1954). This procedure, described earlier in detail (Fazekas *et al.* 1979), is used regularly. The reaction is modified to a final volume of 2.5 ml, resulting a 4-fold increase in sensitivity.

Extinction was measured for the inorganic P at 720 nm 30 minutes after the mixing of the reaction mixture, while the other samples were measured 24—25 hours after the hydrolytic release of P (full development of colour) from N—P bonds. The results are given in μmol. The colour intensity of the peaks in the case of Pi shows an (average) increase of 57.2% after 24—25 hours. 47—50% of this increase occurs within the time interval 0.5—6 hours and 10% between 6 and 24 hours (Fig. 6). It is therefore reasonable to read off values of N—P phosphates from standard curves prepared for the amino acid phosphates.

The chromatogram was drawn on the basis of the P content of the effluent, and only tubes containing P were collected. The specific Arg, His and Lys reactions were also performed with samples taken from the fractions collected.

The Si control examinations were carried out by chromatographically testing a 35.7 μmol Silicon AAS standard solution (purchased from Pearce Inorganics B. V., Rotterdam), and by the chromatographic separation of the hydrolysate from the blank alkaline hydrolysis performed without protein in the borosilicate glass tubes. For the sake of comparison the colour intensity of tubes giving positive responses to molybdate was also read after a 24—25 hour interval.

To check the actual P content, a few samples were hydrolysed in thick-walled (6 mm) teflon ampules with a capacity of 10 ml, furnished with screw-caps. In the course of pilot experiments 3 mol KOH was found to dissolve a UV-positive substance from the wall of the teflon ampule. After repeated use the quantity of dissolved material decreased. However, the chromatographic separation of the amino acid phosphates for protein hydrolysates of teflon are difficult to separate. Knowing the chemical structure of teflon, free radicles with a complicated fluoride content were expected to dissolve from the wall of the teflon ampule, and these are likely to react with the amino acids at such high temperatures. It is therefore more expedient to use glass ampules in the future and to avoid using teflon ampules except for control purposes when checking the hydrolysis of certain amino acid phosphates.

The above led us to try to find and elaborate further specific reactions which make the determination of P content in the elution fractions possible even in the presence of Si. The following reaction mixture was developed after PAUL (1965) for the specific determination of the P content: 0.5 ml sample, 0.25 ml 70% $HClO_4$, 0.5 ml molybdate reagent, 1 ml distilled water, 0.25 ml 1% ascorbic acid, giving a final volume of 2.5 ml. The tubes containing Pi react rapidly with molybdate reagent and they were read at 720 nm in the 30th minute, while the colour intensities of tubes containing organic P were read 24 hours later. The reaction enables a P content of 0.025—0.2 μmol to be determined in the presence of Si.

$HClO_4$ immediately causes the total Si content to polymerize and precipitate, so this does not react with the molybdate reagent. A convincing proof of this can be given by adding commercial Silicon (Pearce) to the reaction mixture.

If information is required on the presence of Si, $HClO_4$ is replaced by 0.25 ml distilled water. Molybdate reagent is added, then after the silicomolybdate has formed (10 minutes) 1 ml 10% citric acid is added. After the development of the citrate complex (15 minutes) 0.25 ml 1% ascorbic acid is added and when the colour appears it can be read of in the 30th minute as above.

The RNA content of the specimens was determined with the orcinol method of SCHNEIDER (1957), and the nucleotide content was checked spectrophotometrically by the method of ASAKURA (1961) in perchloric acidic supernatant, or if necessary it was quantitated after the chromatographic separation.

The presence of arginine was determined on the basis of the arginin-specific Sakaguchi reaction according to the modification of GILBOE—WILLIAMS (1956) adjusted to one-fifth volume.

The histidine content was followed in some cases with the Pauly reaction modified by SLUYTERMAN (1960), but more often by the method of HORINISHI *et al.* (1964), since 5-amino-1-H-tetrazole reacts with the imidazolyl residue of histidine in peptides and proteins alike.

Lys was identified on the basis of the reaction elaborated by CHINARD (1952) for ornithine, but the colour intensity was read at 435 nm, the maximum light absorption characteristic of Lys (and not at 515 nm which is characteristic of ornithine and proline). The Chinard reagent contains large quantities of P (6 mol H_3PO_4) and ninhydrin, so it is advisable to carry out the identification of Lys as the last step, and to wash and store the test tubes and pipettes used for the reaction separately. The yellow colour of the reaction and its intensity before boiling call attention to the presence and quantity of proline.

If the TLC method (Thin Layer Chromatography) is to be applied for some or all of the three amino acid phosphates present, the phosphates are released by hydrolysis with 2 mol HCl and are separated and demonstrated on sheets of "Fixion Fertigfolien" (Chinoin, Budapest) containing a thin cation-exchange Dowex resin layer, according to the method of SAJGÓ—DÉVÉNYI (1972).

It should be mentioned here that in the course of control tests on the systematic amino acid phosphates, P-Arg, P-Lys and P-His show 3, 2 and 1 peaks, respectively. As a consequence of the basic hydrolysis, decarboxylation and hydrolytic (carbamoyl-P) products appear from P-Arg while only decarboxylation products appear from P-Lys and P-His. These accompany the amino acid phosphates in the chromatographic separation. Nevertheless, ion-exchange chromatography does not cause difficulties from the point of view of identification, as each product is eluted within the $KHCO_3$ concentration range described above. Furthermore, in the course of TLC separation the phosphates and their products are eluted in the order Arg, Lys, His (even Me-His). A difference is only observed in the Rf-s of basic amino acids and their hydrolytic products when the plates are subjected to chromatography in a buffer with a pH lower than 3.3 but with an ion intensity similar to that given by Sajgó—Dévényi. When examining the different fractions it was found that the method described above worked with very good selectivity, because the column of Dowex ion-exchange resin was able to bind only Glu, Asp and a few cyclic amino acids owing to the ionic strength and basic pH (0.01—0.02 mol KOH) used.

As mentioned in the methodological section the basic hydrolysis of myosin was studied in ampules made of various materials, and of these, "Pyrex" borosilicate glass ampules were chosen for the current examinations. The concentration of Si dissolved from the ampules was therefore followed with attention. Since the ampules were intended to be used a large number of times care was taken to remove as small as possible a piece from the sealed, thinned end when they were opened. The blank hydrolysate was precipitated by centrifuging with 5% $HClO_4$, after which it was washed, dried and gravimetrically weighed. Figure 1 shows the concentrations of Si dissolved from two experimental ampules, and the development of an equilibrated dissolution (Fig. 1).

As seen in the figure, most silicates dissolve during the first hydrolysis. After the fifth hydrolysis the dissolution of a Si concentration leading to equilibrium is characteristic.

From a mixture of synthetic amino acid phosphates (4 μmol of each) the individual amino acid phosphates can be separated quite well in the manner shown in Fig. 2. They can be differentiated and identified on the basis of their specific reactions. In the figure arrows ndicate the change of $KHCO_3$ in the reservoir, i.e. the application of the partial linear gradient

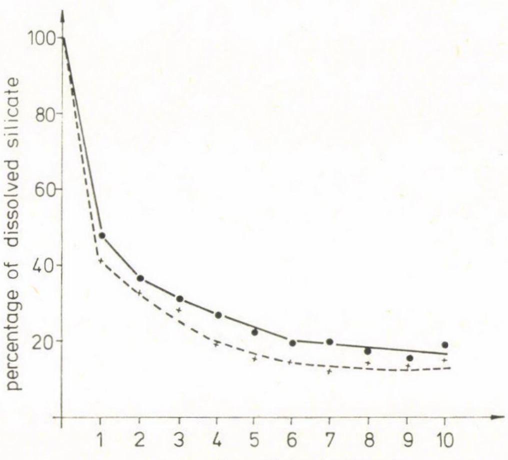

Fig. 1. Dissolved silicate concentration from the inner surfaces of "Pyrex" borosilicate glass ampules. The total surface 36—37.5 cm^2, 100%, is equal to 89 and 95 mg dry weight of silicate for ampules stored in saturated KOH before use. 1 and 2 are the numbers of the examined ampules

method, which is justified by the elution of P-Arg at a low $KHCO_3$ concentration, the close peaks of Pi and P-Lys and the relatively high elution of P-His.

The chromatogram of the amino acid phosphates in the 23-hour myosin hydrolysate is shown in Fig. 3. As seen in the figure, two minor peaks appear before P-Arg, representing the hydrolytic products of P-Arg: the decarboxylation product of P-Arg and carbamoyl-phosphate. Myosin purified on DEAE-cellulose contains no RNA and a negligible amount

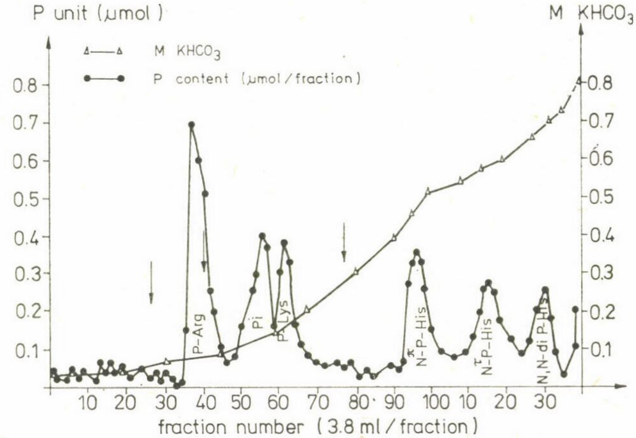

Fig. 2. Chromatographic separation of alkali-stable amino acid phosphates on Dowex 1 X-8 (0.9×22 cm) column. The synthetic mixture contains 4 μmol of each compound

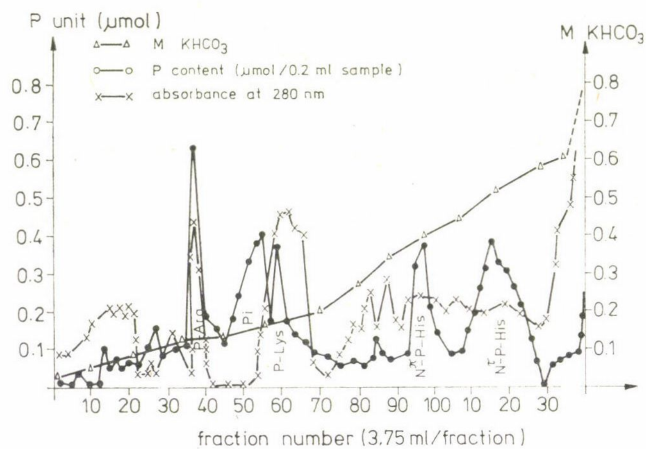

Fig. 3. Chromatographic separation of alkali-stable amino acid phosphates from hydrolysate of myosin on Dowex 1 X-8 (0.9×22 cm) column. The myosin was hydrolysed with 3 mol KOH for 23 hours in sealed tubes in the presence of 0.2 mmol cysteine to prevent the disintegration of tryptophane. The pH of the hydrolysate was adjusted to 11—12 and stored at 2 °C so that the bulk of the dissolved silicate become polymerized and formed a crystalline precipitate. The sediment was removed in a centrifuge, then the supernatant was diluted to 0.01—0.02 mol KOH concentration and applied to the column. The elution was performed with the linear gradient method using a mixing vessel with a capacity of 165 ml and changing the $KHCO_3$ solution in the reservoir four times for solutions of ever increasing concentration (0.2, 0.5, 0.75 and 1.0 mol)

(0.1—0.3 mol) of nucleotide, so the inorganic P can only come from P-Ser (P-Thr), particularly as the hydrolysis is always carried out on lipid-free myosin.

It is due to the low Pi content that P-Lys appears as a single peak in the figure. Besides the theoretically expected amino acid phosphates (P-Arg, P-Lys, P-His), their hydrolysis products and Pi, there are further peaks giving a positive reaction to molybdate, which originate from the Si content of the elution product, as demonstrated by the P-selective reaction.

Since the amino acid phosphates are eluted in the neighbourhood of acidic amino acids which show similar characteristics, the extraction of pure derivatives requires further purification with gel or paper electrophoresis or with TLC, so as to obtain crystallized fractions. The characteristic features of the specimens correspond to those described above. In the present paper emphasis is laid on the clarification of the Si background.

If the blank hydrolysis products are separated chromatographically the Si background can be clarified, as seen in Fig. 4. In the figure many small peaks are seen, which appear in response to the ammonium molybdate reagent. These were measured, as were those from the hydrolysate containing protein, in 0.5 ml samples in a reaction mixture with a final volume of 2.5 ml.

It can be seen that the silicon standard used as control delivered as an alkaline solution with a NaOH concentration higher than 1 mol, and which is applied on the ion-exchange resin column without direct hydrolysis and dissolved in highly concentrated alkali, is eluted under the influence of the elution medium (0.2 mol $KHCO_3$ in the reservoir) mainly in a number of peaks in the first part of the chromatogram. In other words, the silicon standard also becomes polymerized.

It is only when the pH of the hydrolysates has not been reduced to 11—12 and they are applied to the column without storage that they show higher and more numerous Si peaks

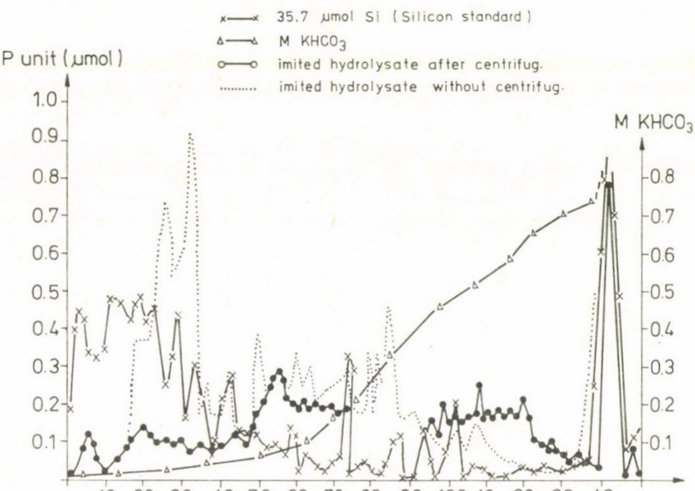

Fig. 4. Comparison of the peaks of silicon standard and blank hydrolysates gained by chromatographic separation on a Dowex 1 X-8 (0.9×22 cm) column. As 10 µmol silicate showed too low a background for comparison, 35.7 µmol silicon standard (×———×) was applied to gain an expressive peak series which appeared in most cases in the first part of the chromatogram. One of the blank hydrolysates (· · ·) was prepared without pH adjustment and storage, while the other (|—|) is a pH-corrected hydrolysate free of silicate precipitate

in the low concentration range of $KHCO_3$. The reduction of pH in the hydrolysate induces the polymerization of the silicates in this case, too. The gradual increase in the degree of Si-polymerization continues during storage; they are transformed into a crystallized sediment and can be removed almost completely by centrifugation. The remaining polymer, which is made up of a larger number of molecules, is eluted at the end of the chromatogram in a high peak under the influence of 1 mol $KHCO_2$.

Figure 5 compares the chromatogram of the blank hydrolysate containing Si with that of the myosin hydrolysate containing amino acid phosphate (in an ampule used on three occasions).

It can be seen that in the presence of P-Arg, P-Lys and P-His the area and height of the peaks at the appropriate sites of elution increase and become conspicuous. At sites containing amino acid phosphates the Pi released shows increased colour intensity in response to the acidic molybdate reagent, and the specific reactions confirm the presence of the corresponding basic amino acids. Therefore the detection and identification of basic amino acid phosphates does not cause any special difficulty.

As mentioned in the methodological section, the colour intensity of the hydrolysates is measured in the 24—25 hours interval in an acidic reaction mixture containing molybdate and ascorbic acid, and the inorganic P shows a 57.2% increase compared to the 30th minute. Time-dependent changes in the increase in colour intensity for samples containing inorganic P are shown in Fig. 6.

In the presence of ascorbic acid, turbidity or discoloration, like that found in reaction mixtures containing $SnCl_2$ or 1-amino-2-naphthol-4-sulphonic acid-sodium sulphite, cannot be observed even after 36 hours, so the method can be successfully used to determine the P content even in the case of organic N—P bonds, as the hydrolysis of these is usually completed by the 10th to 16th hour.

Figure 7 shows the dissolution of Si from a pyrex glass ampule used on the 10th occasion for blank hydrolysis.

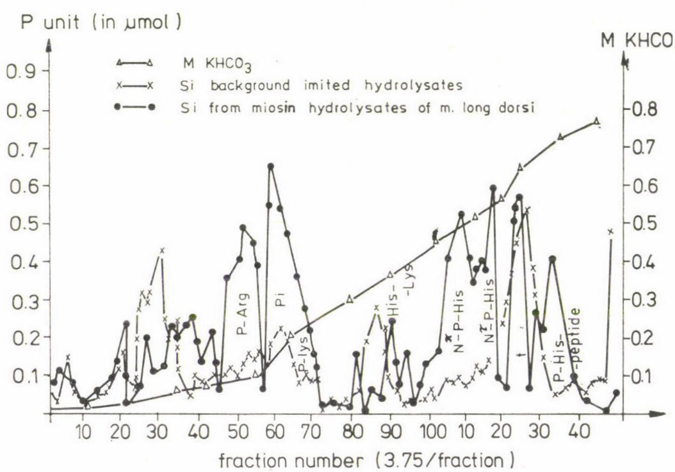

Fig. 5. The chromatogram shows a blank hydrolysate and an m. long. dorsi myosin hydrolysate separation on the same Dowex 1 X-8 ion-exchange column. At about 0.35 mol $KHCO_3$ concentration the chromatogram shows several small His and Lys peaks containing small quantities of P too

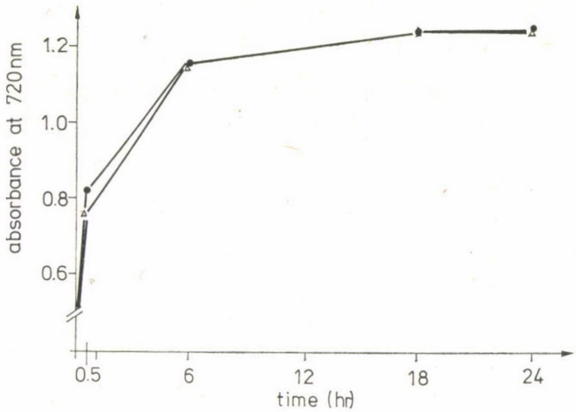

Fig. 6. Increase in the colour intensity of inorganic P in the course of time. Colour changes are indicated in two parallel samples in a reaction mixture of acidic molybdate and ascorbic acid

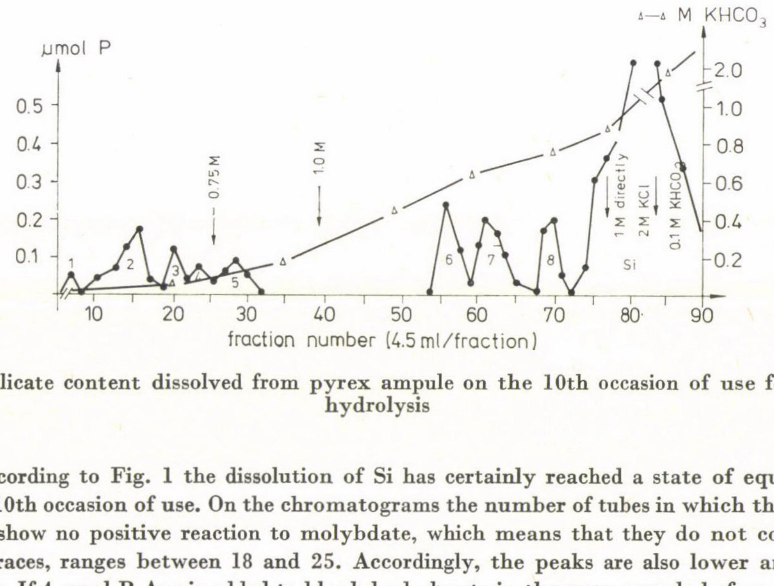

Fig. 7. Silicate content dissolved from pyrex ampule on the 10th occasion of use for blank hydrolysis

According to Fig. 1 the dissolution of Si has certainly reached a state of equilibrium after the 10th occasion of use. On the chromatograms the number of tubes in which the elution products show no positive reaction to molybdate, which means that they do not contain Si even in traces, ranges between 18 and 25. Accordingly, the peaks are also lower and fewer in number. If 4 µmol P-Arg is added to blank hydrolysate in the same ampule before applying it to the ion-exchange resin column, P-Arg will appear in the first part of the chromatogram (Fig. 8) in a high peak which covers up the four low Si-containing peaks.

For the sake of comparison, Fig. 9 shows the chromatogram of 1 µmol P-Arg hydrolysate. Before separation P-Arg was hydrolysed at 90 °C for 6 hours in a teflon ampule used on the fifth occasion. In spite of the moderate hydrolysis, besides P-Arg its hydrolysis product can also be seen on the chromatogram. If the sample is hydrolysed under conditions similar to those required for the hydrolysis of proteins (105°C, 10—20 hours), the hydrolysate of P-Arg will also show many small molybdate-positive peaks. The chromatogram cannot be analysed, and the Dowex column, especially after protein hydrolysis, becomes unsuitable for further separation. Subsequent experiments have revealed that when P-Arg is hydrolysed in teflon and glass ampules and then separated, it shows 3 peaks on the chromatogram. Of these the

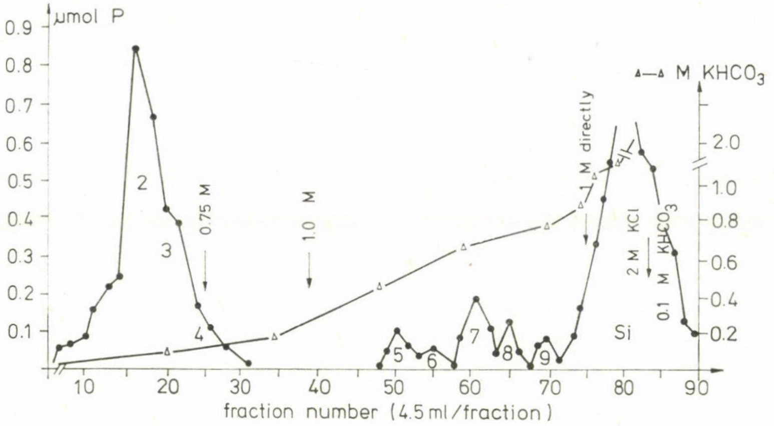

Fig. 8. Chromatography of 4 µmol P-Arg with blank hydrolysate using the pyrex ampule for hydrolysis for the tenth time. P-Arg was mixed with the hydrolysate before it was applied to the Dowex 1 X-8 colxmn

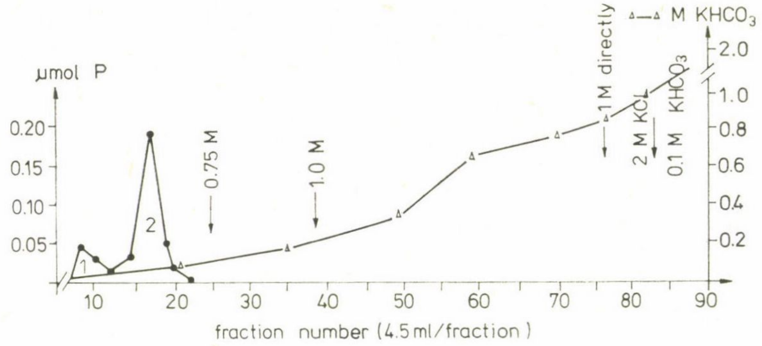

Fig. 9. Chromatography of 1 µmol P-Arg hydrolysate using a teflon ampule for hydrolysis. P-Arg was hydrolysed in 3 mol KOH at 90 °C for 6 hours. 1. Hydrolysed product of P-Arg; 2. P-Arg

decarboxylation product of P-Arg is the first to be eluted. Both hydrolytic products are small in quantity and all three compounds (P-Arg and its hydrolytic products) are eluted within the range described in the methodological section.

Finally, attention must again be called to the fact that P-containing fractions obtained from large amounts of myosin and freed from salt on a Sephadex 10 column can be lyophilized and crystallized. If the production of the barium salts is sufficient for the purposes of the experiment, it is unnecessary to remove the salts. After storage at 4 °C with the addition of 1 mol barium acetate and 2 volumes of ethanol the amino acid phosphates precipitate in an almost totally pure state. Good results can be attained with chromatographic separation on Whatman No. 1 paper, since the amino acid phosphates, particularly when only one of them is present, accumulate in a single strip well separated from the salts. The concentrate is applied on the groundline of the chromatographic paper in the form of a single strip, and separated by the ascending chromatographic method described in detail in a previous paper (FAZEKAS *et al.* 1976a).

The present investigations suggest that, in contrast to the generally accepted view, the presence of acid-labile N—P type phosphates, bound to amino acid residues in the peptide chains of myosin, must be expected when dealing with muscular functions and muscle capacity. Indeed, these may well play a decisive role in the mechanism of contraction. Myosin is regarded as an autophosphorylation system, which presumably becomes phosphorylated and dephosphorylated when built into the filamentary structure during contraction. Phosphorylation mainly increases the labile N—P type phosphate content and reduces the actin (FAZEKAS *et al.* 1979). Consequently this paper deals primarily with the hydrolysis, separation and identification of the basic amino acid phosphates occurring in myosin.

In earlier studies it only proved possible to demonstrate the presence of P-His (FAZEKAS *et al.* 1976a, b). The present method is also suitable for detecting the occurrence of P-Arg and the small quantity of P-Lys in the myosin of m. long. dorsi. Attention is drawn to some complementary information concerning the method.

Due to an increase in the time interval the alkali hydrolysis of the myosin reaches completion. This, however, involves the disadvantage of minor peaks (the hydrolytic products of Arg, His, Lys and perhaps Me-His), which are found in several places on the chromatograms. Another natural consequence of the prolonged hydrolysis is the increased dissolution of the silicate. It was to overcome these difficulties that the determination of P accompanied by Si was elaborated. The improvement on the method devised by PAUL (1965), who was the first to develop a technique for the parallel determination of Pi and Si, lies in the fact that polymerized Si does not absorb Pi, so the method can be used with 100% reliability for determining the P contents of basic hydrolysates. Having failed to find better quality glass or other materials for making ampules, the "Pyrex glass" type is used, with a hydrolysis time of 10—22 hours, which is thought at present to be optimum. Here it must be emphasized once again, that if the currently accepted alkali concentration, time of hydrolysis and temperature are used even teflon ampules give a heterogeneous hydrolysis product, which means that the chromatogram is impossible to analyse and the Dowex resin column becomes unfit for use.

For protein hydrolysis glass ampules used on a number of occasions are the most suitable, because the dissolution of silicate then reaches a state of equilibrium. In ampules opened after the hydrolysis, CO_2 is absorbed during storage; consequently the Si is polymerized and the introduction of CO_2 completes the precipitation of the polymerized silicate. After the removal of the precipitate the hydrolysate shows only a few Si-containing peaks in the first part of the chromatogram. It is only at the end of the chromatogram that a considerable amount of silicate polymer is eluted in response to 1 mol $KHCO_3$. Fortunately, this does not affect the free amino acid phosphate content of the fraction, and only if the time of hydrolysis is shorter does it show a negligible quantity of P-peptide. When the chromatographic column is regenerated the Si (2 mol $KHCO_2$, 2 mol KCl) is completely eluted.

Finally, it should be mentioned that the total P content of the hydrolysate is bound on the Dowex 1 X-8 column at the low KOH concentration (0.01—0.02 mol) used. Only Glu, Asp and the aromatic amino acids become bound at this alkali concentration, but even these are not bound completely. This is why the quantitative determination of the individual amino acid phosphates has an accuracy of only 85—92%. From the calculations it can be concluded that, in addition to 4 mol P-His, about 4 mol P-Arg and a minor quantity of P-Lys (maximum 1 mol) occur in the m. long. dorsi myosin of rabbits (chinchilla).

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MORPHOLOGICAL COMPARISON OF LOCAL HEMP VARIETIES

Hemp is one of the most ancient cultivated plants, grown mainly for its fibre content (Mándy—Bócsa 1962). The fact that in warmer climatic zones *Cannabis sativa* produced special substances with strong physiological effects was discovered very early and this initiated its use for therapeutical purposes in various cases, e.g. to relieve pain; as a disinfectant, sedative or antispasmodic substance; against tetanus and rheumatism; to cure various toxicoses, etc.

In modern medicine drugs prepared from hemp are not used, but in certain countries hemp is widely used as a popular medicine, and its biologically active substances, which have recently been produced, are being subjected to detailed pharmacological analyses (in UN laboratories, in research laboratories in the United States and other countries). The cannabinoid-type compounds detected during the chemical analyses, most of which have already been defined, accumulate in the bracts of the female inflorescence and also in other parts of the plant (foliage leaf, stem).

Since the utilization of the resin (hashish) produced in the female inflorescence of the plant as a narcotic has assumed universal dimensions, particularly over the last ten years, detailed investigations are being carried out, following a UNO decision (ANONYMOUS 1974), on various aspects of hemp including

- extraction and analysis of cannabinoids and substances left behind after the extraction, etc.;
- pharmacological studies on hemp with special regard to the minor components;
- biological studies on hemp, e.g. search for different geographical varieties of hemp in connection with the biosynthesis of cannabinoids.

With this object in mind it was decided that the available geographical varieties of Cannabis sativa, particularly those which had attracted the attention of the UNO narcotics laboratory, should be collected and grown under identical conditions. The aim was to compare these local varieties with other European hemps, mainly in order to acquire a closer chemotaxonomic knowledge of the biosynthesis of cannabinoids.

Hemp originating from the following places: Mexico (UNC 347), Thailand (UNC 254), Spain (UNC 484) and South Africa (UNC 134), was grown at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, in 1977 and 1978. The seeds were obtained from the UNO narcotics laboratory. For comparison the Hungarian Kompolt hemp was used.

In 1970 vegetation experiments were also carried out with two Turkish hemps under the names Turkish I and Turkish II.

Thousand-seed-weights

	$\bar{x}$	s
Mexican	10.05 g	0.32
Thai	14.00 g	0.24
Spanish	20.12 g	0.25
South-African	8.99 g	0.14
Turkish I	19.99 g	0.24
Turkish II	21.03 g	0.34
Kompolt	20.00 g	0.31

The plants were grown in the field under natural conditions, in 4.5 m^2 plots with 50 cm row distance and 20 cm plant distance after thinning.

When the next survey was carried out the plant distance was 40 cm, and by the end of the experiment it was 80 cm, the missing plants having been removed for morphological and chemical examinations.

In 1977 sowing took place on three dates: 12th April, 26th April and 11th May.

Considering the date and percentage of germination the second sowing proved the best, so in 1978 only one sowing date was used, 26th April.

The seed of South-African hemp was not germinable. In the case of the Mexican and Thai hemps the germination period was shorter in 1977 than in 1978; the other local varieties showed no difference in this respect. As to the germination percentage, in 1978 it was higher for the Mexican and lower for the Thai hemp than in 1977; the germination percentage of the Spanish hemp was approximately the same in the two years, while for the two Turkish hemps it was higher in both years compared to that of the other foreign hemps (Table 1).

Table 1

Time and percentage of germination in hemp

1977

Variety	1st sowing		2nd sowing		3rd sowing	
	time	%	time	%	time	%
	of germination					
Mexican	—	—	10	31.2	15	20.6
Thai	16	10.0	8	37.5	15	11.9
Spanish	10	25.0	6	25.0	10	12.5
Kompolt	9	40.0	6	81.9	7	70.0

1978

Variety	Sowing: 26th April	
	time	%
	of germination	
Mexican	13	37.4
Thai	13	34.4
Turkish I	6	43.8
Turkish II	6	45.0
Spanish	6	25.0
Kompolt	6	78.1

The first two sampling dates were dependent on the developmental stage, while the last four dates were fixed. Accordingly: (see 353 p.)

The first sample consisted of 10 plants and the others of 5 plants per sampling.

The annual mean temperature in 1977 exceeded the average over many years by one degree. The winter was particularly mild, the mean temperature for the three winter months being 2.1°C lower than average. Spring was also 1.5° C warmer than usual. The mean temperature for the summer months was slightly below the average over many years.

The number of sunshine hours during the crop year was 459, less than average; it was only in March that there was somewhat more sunshine than usual. In the summer months the number of sunshine hours was 322 less.

The total amount of precipitation was 22 mm more than average. There was 105 mm more precipitation than usual in the winter half of the year and 83 mm less than usual in the summer half. The amount of precipitation stored during the winter months was only able to moderate the drought at the beginning of the growth season.

The annual mean temperature in the year 1977/78 was 0.2 °C higher than the average over many years. The winter half of the year was one degree warmer and the summer half 0.6 °C cooler than usual. Autumn was somewhat warmer than usual. The mean temperature of the winter months was 0.7 °C lower than average. Spring was 0.6 °C warmer and summer 1.1 °C cooler than usual. The total number of sunshine hours in the crop year was 382 less

Local variety	1977 date	1977 number of days	1978 date	1978 number of days
Sample I: Plants at the 4-leaf stage				
Mexican	23rd May	27	21st May	25
Thai	23rd May	27	21st May	25
Spanish	16th May	20	16th May	20
Kompolt	16th May	20	16th May	20
Turkish I	—	—	16th May	20
Turkish II	—	—	16th May	20
Sample II: Plants at the 12-leaf stage				
Mexican	10th June	45	10th June	45
Thai	15th June	50	10th June	45
Spanish	31st May	35	28th May	32
Kompolt	31st May	35	31st May	35
Turkish I	—	—	31st May	35
Turkish II	—	—	31st May	35

	1977/1978 date	number of days
Sample III:	12th July	77
Sample IV:	16th August	112
Sample V:	20th September	147
Sample VI:	18th October	175

The figures represent the number of days from sowing.

(98 hours less in the winter half-year and 284 hours less in the summer half) than the average over many years. In the whole farming year it was only in October that the number of sunshine hours slightly exceeded the average over many years. The plants were most seriously affected by the deficiency of sunshine in April, May, June and July (64, 81, 60 and 44 hours less, respectively).

The total amount of precipitation was 93 mm less than the average over many years, being 78 mm less in the winter half-year and 15 mm less in the summer half. Of the four seasons it was only in spring that the amount of precipitation exceeded the average, and even then only by 1 mm. In the period from April to July there was 31 mm more precipitation than the average over many years.

On the first and second sampling dates the types examined showed no significance morphological differences; with respect to the rate of development the non-European hemps were about 1 week behind.

By the third sampling date none of the varieties examined had yet entered the generative phase of development; buds had only appeared on a few Spanish male plants.

At the fourth sampling date the Mexican and Thai hemps were still in the vegetative phase of development, while the other four local varieties had already differentiated into male and female plants. Buds were found in each case in the upper part of the shoot. In the Kompolt hemp in both years, and in the Spanish hemp and the Turkish I local variety in 1978, fruits were also found.

On the fifth sampling date in 1977 male plants of all four local varieties were at the flowering stage, while buds could be seen on the male plants from Mexico and Thailand. In 1978 the Mexican and Thai hemps were in the same stage as in 1977, both Turkish hemps were flowering, and the male plants of the Kompolt variety had already withered. At the same time the female plants of the Mexican and Thai hemps were in the flowering phase, and the other four local varieties had ripe fruits, though some of the fruits were still green.

The last samples taken from Mexican and Thai male hemps consisted of flowering plants; in the other four varieties the male plants had already withered. At the last sampling date green fruits were observed on the female plants of Mexico and Thailand, and the plants had begun to wither. The two Turkish, the Spanish and the Kompolt hemps were at the ripe fruit stage in 1977; green fruits were not found. In 1978 the female plants of the Spanish and Kompolt hemps had withered by the last sampling date.

According to Quimby *et al.* (1973) the habits of hemps can be: *a)* conic, the lower branches are the longest and the upper ones the shortest; *b)* columnar, the lateral shoots grow upwards, close to the stem; *c)* procumbent with irregular lateral shoots.

Although, identical conditions were ensured for the plants during the growing period, the habits remained characteristic of the respective local varieties.

Of the hemps examined, those from Mexico and Thailand were conic, while the other four local varieties were columnar (Fig. 1a).

Procumbent plants were not found in any of the varieties examined.

On the basis of differences in the date of germination the hemps examined can be divided into two groups (Table 2). The Mexican and Thai hemps, which have longer germination periods, form one group, while the other four local varieties belong to the other. The vegetation of the Spanish, Kompolt and the two Turkish hemps lasted 130—140 days and led to fruit ripening. The Mexican and Thai hemps entered the generative phase of development late in autumn, and the vegetation period ended at the green fruit stage. Owing to the climatic conditions the plants did not reach full maturity by the end of the vegetation period. No substantial difference was observed between the two growing seasons.

The male plants were generally taller than the female ones, with the exception of the Spanish hemp whose female specimens grew taller in both years. The greatest difference between

Table 2

Phenology of hemp

	Germination		12-leaf stage		Budding		Flowering		Ripe fruit stage	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Mexican	10	13	45	45	118	124	130	130	—	—
Thai	8	13	50	45	126	132	135	140	—	—
Turkish I	—	6	—	35	—	80	—	85	—	130
Turkish II	—	6	—	35	—	80	—	85	—	130
Spanish	6	6	35	32	70	80	85	90	140	135
Kompolt	6	6	35	35	80	85	90	90	140	140

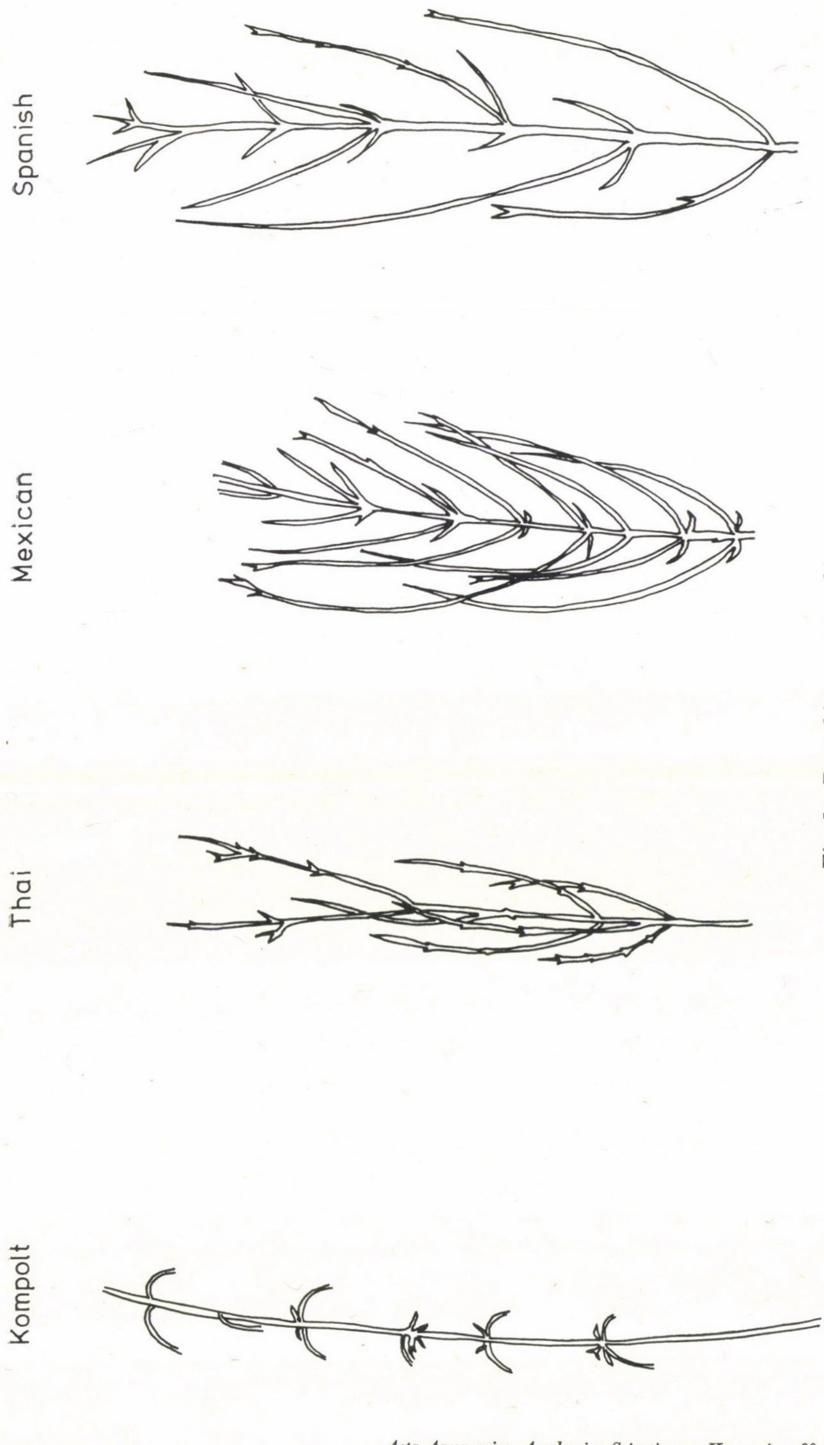

Fig. 1a. **Branching system of hemp**

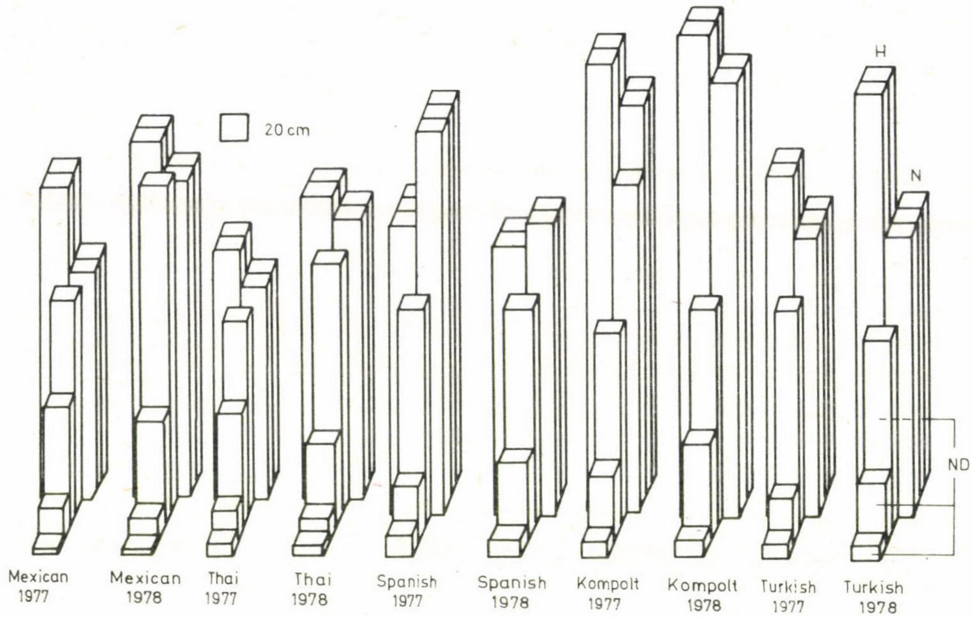

Fig. 1b. Height of hemp

Table 3

Effects of variety, sex and year on shoot length. Comparison of varieties for shoot length

	Kompolt	Spanish	Mexican
Variety	$\bar{x} = 305.78$	$\bar{x} = 222.41$	$\bar{x} = 212.05$
Thai $\bar{x} = 183.52$	122.26^{++}	38.9^{++}	28.53^{++}
Mexican $\bar{x} = 212.05$	93.73^{++}	10.36	
Spanish $\bar{x} = 222.41$	83.37^{++}		

$LSD_{5\%} = 16.12\ (16.82)$
$LSD_{1\%} = 19.72\ (20.58)$

Effect of sex on shoot length
male − female = 15.74^{++}

$LSD_{5\%} = 7.92\ (8.08)$
$LSD_{1\%} = 10.54\ (10.75)$

Effect of year on shoot length
1978 − 1977 = 16.19^{++}

$LSD_{5\%} = 7.92\ (8.08)$
$LSD_{1\%} = 10.54\ (10.75)$

Note: In Tables 3 and 4 two LSD values are given, because in the case of Spanish male hemp in 1977 the number of repetitions was smaller than in the other cases. In the values in brackets the results of Spanish male in 1977 are taken into account.

male and female plants was found for Turkish II hemp, where the former were 33% higher than the latter.

The male plants were 18% taller than the female ones in Turkish I; 11% taller in 1977 and 9.3% taller in 1978 in Kompolt; 14.3% taller in 1977 and 7.6% taller in 1978 in Thai hemp, and 30.8% taller in 1977 and 11% taller in 1978 in the Mexican variety.

In the case of the Spanish hemp the female plants were 23.5% taller than the male ones in 1977 and 7.4% taller in 1978. When considering the differences in height between male and female plants in the two growth seasons it is found that these differences were greater in 1977 than in 1978. The Mexican, Thai and Kompolt hemps grew taller in 1978 than in the previous year, while the Spanish hemp was taller in 1977. As to the absolute height, Kompolt was the tallest and the Thai hemp was the shortest (Fig. 1b).

The Kompolt hemp was significantly taller and the Thai significantly shorter than the other local varieties. No significant difference in height was found between the Spanish and Mexican hemps (Table 3). The male plants of the Kompolt hemp were significantly taller than those in the other local varieties examined, where no statistically significant difference could be observed in this respect. The female plants of the Kompolt hemp were also significantly taller than those of the other local varieties. With the exception of the Spanish hemp the male plants were taller than the female ones in all the local varieties (Table 4).

The Thai and Mexican hemps grew significantly taller in 1978 than in 1977. The same tendency was observed in the case of the Kompolt hemp, though the difference was not

Table 4

Average shoot lengths in the comparison between varieties and sex, and varieties and year

Interaction between variety and sex

	Male	Female
Thai	193.80	173.25
Mexican	233.85	190.25
Spanish	195.64	241.15
Kompolt	321.35	290.20

$LSD_{5\%} = 34.83\ (38.38)$
$LSD_{1\%} = 42.61\ (46.95)$

Interaction between variety and year

	1977	1978
Thai	162.95	204.10
Mexican	190.00	234.10
Spanish	252.43	201.40
Kompolt	294.95	316.60

$LSD_{5\%} = 34.83\ (38.38)$
$LSD_{1\%} = 42.61\ (46.95)$

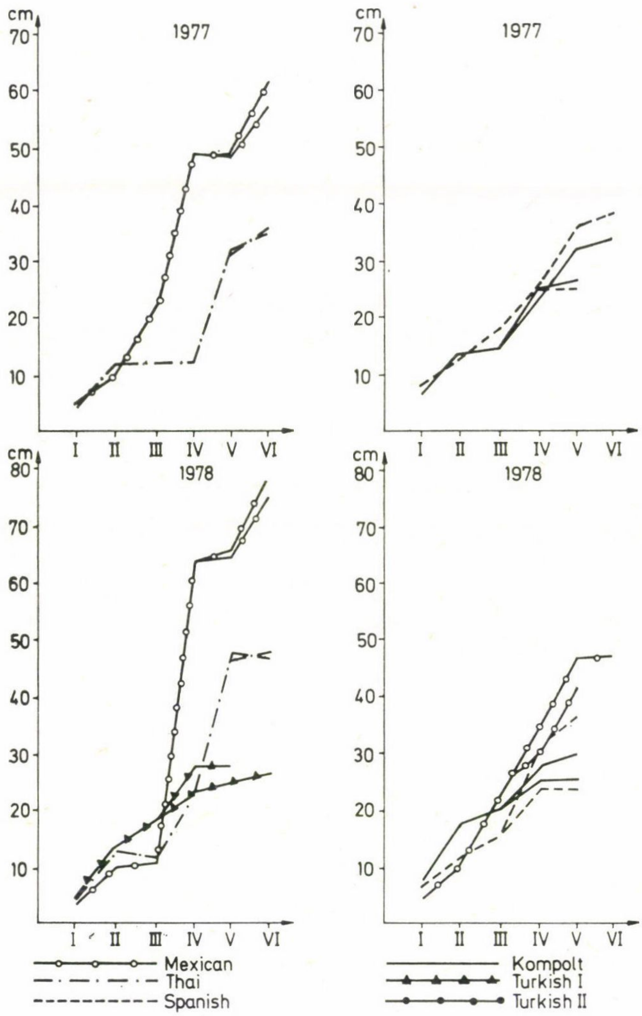

Fig. 2. Growth dynamics of hemp root

significant. The Spanish hemp, on the other hand, showed the opposite tendency, i.e. it was taller in 1977.

The male plants of Turkish II were significantly taller than those of the Spanish, Thai and Turkish I hemps. The male plants of Turkish I were significantly shorter compared to those in the varieties Kompolt and Turkish II. As to the heights of the female plants the hemps examined showed the following order: Kompolt, Mexican, Spanish, Turkish II, Thai and Turkish I, though significant differences were only found between the Turkish I and II and the Kompolt hemps. In both Turkish hemps the male plants were significantly taller than the female ones.

With regard to the growth dynamics it can be established that growth in the Mexican and Thai hemps continued up to the fifth sampling date in autumn, when the ontogeny enters the generative phase. In the other four geographical types growth stopped after the fourth sampling, which also means a transition to the generative phase from a phenological point of view. Thus, in all cases growth lasts until the generative phase. Growth between the third and fourth sampling dates was particularly intensive in the Kompolt hemp, where the height of the plant at the third sampling was only 50% of that at the fully developed stage.

Within the same sample the widest standard deviation was observed in the Mexican and Thai hemps at all six sampling dates. Within the same geographical race the widest deviation was found in samples taken before differentiation, and the least in fully developed plants.

Root diameter was measured in the zone of transition to the stem at the hypocotyl; by root length the length of the main root is understood. The root of the Mexican hemp does not branch; there are many secondary roots on it. The Thai hemp is characterized by many lateral and secondary roots. The length of the lateral roots may be as much as one and a half metres. The Spanish and Kompolt hemps also have many strong, long lateral roots, while there are only a small number of secondary roots. A small number of lateral roots combined with a strong main root is a common characteristic of the two Turkish hemps, while a difference is found between them in the number of secondary roots, which are numerous in the Turkish I and few in the Turkish II hemp. Root growth in the Mexican hemp showed a sudden change from the third to the fourth sampling (between the 11th and 16th week of vegetation), when the root diameter increased threefold and the root length fourfold when averaged over the two years.

The growth of the root stopped between the 16th and 21st week. Late in autumn, after the 21st week, further root growth could be observed (Fig. 2).

In the Thai hemp, unlike the Mexican hemp, a sudden increase in root growth could be observed from the fourth to the fifth sampling (between the 16th and 21st week of vegetation), then no further root growth occurred. In the case of the Spanish, Kompolt and the two Turkish hemps the diameter and length of the root reached a maximum at the fifth sampling. In the Turkish II, as in the Thai hemp, a sudden increase in root growth was experienced between the fourth and fifth sampling, while in the case of the Spanish hemp this occurred

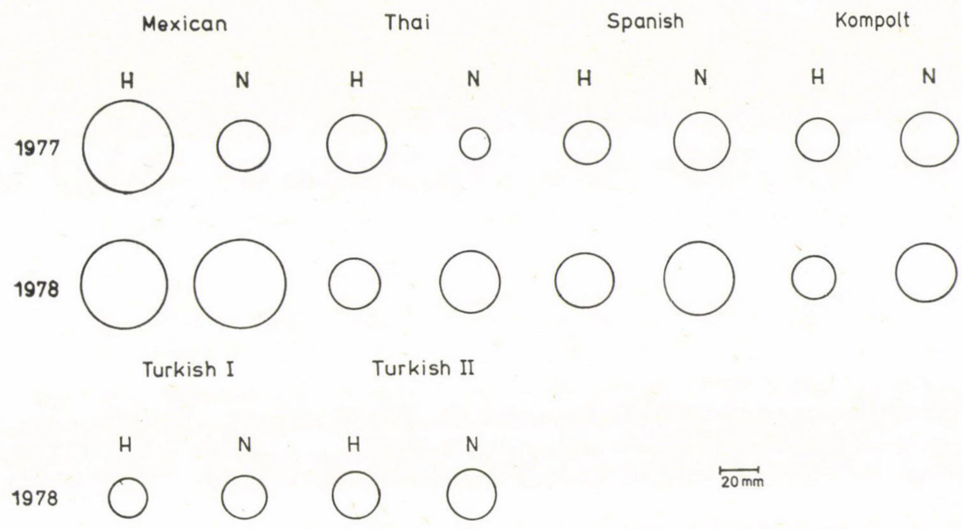

Fig. 3. Comparison of hemp varieties for the diameter of main root

between the third and fourth samplings, as it did in the Mexican hemp. As a common feature of the Kompolt and Turkish hemps, the root growth showed a steady rhythm; no sudden increase could be observed. The Mexican and Thai hemps had stronger root systems in 1978 than in 1977, which is in correlation with the development of the shoot system in these races: the plants themselves were taller in 1978 than in 1977. The Spanish and Kompolt hemps showed no differences in the root diameter or in the length of the main root. In the Mexican and Thai hemps the root diameter in 1977 was considerably larger in the male plants than in the female ones (Fig. 3).

In 1978 the male and female hemps had nearly identical diameters. In the other four races no difference in root diameter between male and female plants could be observed. No differences in root length between male and female plants were found in any of the races.

The Mexican variety had the strongest main root, but the whole root system was the strongest in the Thai hemp, as it had many strong lateral roots.

The hemp plant has palmate compound leaves (Fig. 4a, b, c, d, e, f). The varieties examined are characterized by 5—6 or 7—9 leaflets; the former is characteristic of the Mexican and Thai hemps, while the latter is found in the other four varieties. In all the types examined the first foliage leaves consist of three leaflets. Leaves at the lower nodes and shoot apices consist of fewer leaflets than those found at medium height.

The leaves on the primary, secondary and tertiary branches have the same number of leaflets. There are two forms of leaf position: opposed in the vegetative and scattered in the generative part. In some plants, though this is not characteristic of the species, the leaves are scattered in the vegetative part too.

Leaflet indices were measured in the fully developed plants: at the fifth sampling for the Mexican and Thai hemps, and at the fourth sampling for the other types examined. In each morphologically studied plant, the index was determined for the middle leaflet in five leaves of each of the lower, medium and upper part of the plant. Since the leaflet indices measured at different heights were the same for male and female plants, the indices shown in Table 5 are the mean values of leaflet indices measured at different heights in the male and female plants.

The lower the leaflet index is, the stumpier the lanceolate shape. The indices were nearly identical in the two years; the greatest difference was found in the Thai hemp.

Variance analysis revealed that the trend of the leaflet index was influenced both by the year and by the varietal character (Table 6).

Table 5

Comparison of leaflet indices in hemp

	1977	1978
Mexican	8.03	8.31
Thai	4.51	4.83
Spanish	6.04	6.04
Kompolt	4.63	4.52
Turkish I	—	6.20
Turkish II	—	7.70

$$\text{leaflet index} = \frac{\text{length of leaflet}}{\text{width of leaflet}}$$

Fig. 4. Leaves of hemp varieties *(a)* Kompolt, *(b)* Thai, *(c)* Mexican, *(d)* Spanish, *(e)* Turkish I, *(f)* Turkish II

The trend for the number of leaves during ontogeny is shown in Table 7. Since the first two sampling dates were dependent on the number of leaves, no differences can be seen here in the number of leaves. From the third sampling, on the other hand, differences are shown between the varieties. The six local varieties examined can be divided into two groups, one of which includes the Mexican and Thai hemps, where secondary and tertiary branching had

Table 6

Variance analysis of leaflet indices; effects of variety and year on the leaflet index; leaflet index averages compared with varieties and years

Variance analysis of leaflet index in hemp

Factor	FG	MQ	F	Significance
Variety (V)	3	416.193	2822.210	++
Year (Y)	1	3.168	21.484	++
Interaction (V)×(Y)	3	1.196	8.112	++

Comparison of varieties for leaflet index

	Mexican	Spanish	Thai
Variety	$\bar{x} = 8.17$	$\bar{x} = 6.04$	$\bar{x} = 4.67$
Kompolt $\bar{x} = 4.62$	3.55^{++}	1.42^{++}	0.05
Thai $\bar{x} = 4.67$	3.50^{++}	1.37^{++}	
Spanish $\bar{x} = 6.04$	2.13^{++}		

$LSD_{5\%} = 0.12$
$LSD_{1\%} = 0.15$

Effect of year on leaflet index
$1978 - 1977 = 0.15^{++}$

$LSD_{5\%} = 0.06$
$LSD_{1\%} = 0.08$

Interaction between variety and year

	1977	1978
Mexican	8.03	8.31
Thai	4.51	4.83
Spanish	6.04	6.04
Kompolt	4.63	4.62

$LSD_{5\%} = 0.27$
$LSD_{1\%} = 0.32$

Table 7

Changes in the number of hemp leaves during ontogeny

Sample	Mexican		Thai		Turkish I		Turkish II		Spanish		Kompolt	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
I	4	4	4	4	—	4	—	4	4	4	4	4
II	12	12	12	12	—	12	—	12	12	12	12	12
III	105	84	90	90	—	30	—	32	36	26	30	32
IV H	220	310	160	185	—	80	—	100	80	65	60	60
IV N					—	110	—	125	125	120	80	70
V H	200	305	152	180	—	60	—	80	65	+	+	+
V N	220	330	170	194	—	100	—	105	105	112	65	65
VI H	175	300	150	185	—	+	—	+	+	+	+	+
VI N	185	314	170	200	—	75	—	72	100	+	+	+

+ = withered

Table 8

Changes in the R values of hemp varieties

Variety	Sex	Year	
		1977	1978
Mexican	male	0.34	0.36
	female	0.13	0.08
Thai	male	0.81	0.79
	female	0.87	0.79
Spanish	male	6.04	5.92
	female	4.24	4.52
Kompolt	male	5.22	6.39
	female	6.29	7.00
Turkish I	male	—	3.21
	female	—	4.12
Turkish II	male	—	5.00
	female	—	4.30

$$R = \frac{\text{length of vegetative part (V)}}{\text{length of generative part (G)}}$$

already occurred at the time of the third sampling, so that the number of leaves was many times greater than in the varieties which made up the other group, which only showed primary branching at that time. The maximum number of leaves was reached by all varieties in the 16th week of vegetation. From then on the number of leaves in the two Turkish hemps as well as in the Spanish and Kompolt varieties gradually decreased due to the withering and falling of the lower leaves. In the Mexican hemp the leaves began to decrease in number at the last sampling, while in the Thai hemp no reduction in the number of leaves was observed, which suggests that under different vegetation (climatic) conditions they would continue to develop.

The larger the vegetative part of the plant compared to the generative one, the more it is used for fibre production, while plants with a larger generative part are used for seed

Table 9

Variance analysis of R values in hemp; effect of variety on the R value; average R values in a comparison between varieties and sex

Variance analysis of R values

Factor	FG	MQ	F	Significance
Variety (V)	3	183.621	408.729	++
Year (Y)	1	1.159	2.580	n.s.
Sex (S)	1	1.188	2.645	n.s.
Interaction (V)×(Y)	3	1.115	2.482	n.s.
Interaction (V)×(S)	3	5.146	11.455	++
Interaction (Y)×(S)	1	0.011	0.025	n.s.
Interaction (V)×(Y)×(S)	3	0.155	0.344	n.s.

Comparison of varieties for R value

Variety	Kompolt $\bar{x} = 6.22$	Spanish $\bar{x} = 5.18$	Thai $\bar{x} = 0.81$
Mexican $\bar{x} = 0.23$	5.99^{++}	4.95^{++}	0.58
Thai $\bar{x} = 0.81$	5.41^{++}	4.37^{++}	
Spanish $\bar{x} = 5.18$	1.04^{++}		

$LSD_{5\%} = 0.61$
$LSD_{1\%} = 0.74$

Interaction between variety and sex

	Male	Female
Mexican	0.35	0.11
Thai	0.80	0.83
Spanish	5.98	4.38
Kompolt	5.80	6.64

$LSD_{5\%} = 1.31$
$LSD_{1\%} = 1.59$

production. The smaller the number of nodes and the longer the internodes, the better the quality of fibre produced from the plant. In possession of this knowledge a comparative study was carried out with fully developed plants (Table 8).

As seen from the table the R values are nearly identical for the two years. They range over a wide scale: from 0.08 (Mexican female hemp in 1978) to 7.00 (Kompolt female hemp in 1978). The Mexican hemp, which has the lowest R value, and the Thai hemp have R values below 1.00, thus being suitable for seed production. The other four varieties are fibre hemps, as the vegetative part of the plant is considerably larger than the generative one.

These R values, which remain constant under unchanged conditions and represent a varietal character, also confirm the morphological suitability of the Mexican and Thai hemps to serve as a source in producing psychotropic substances.

The trend of the R value (the length ratio of the vegetative to the generative part) is shown by these investigations to be independent of the sex of the plant, and does not depend on the year either. Substantial differences were found, on the other hand, between the R values of the individual varieties (Table 9). The Kompolt and Spanish hemps have significantly higher R values ($\bar{x} = 6.22$ and 5.18, respectively) than the Mexican ($\bar{x} = 0.23$) and Thai ($\bar{x} = 0.81$) hemps. The R values of the two Turkish hemps ($\bar{x} = 3.67$ for Turkish I and 4.65 for Turkish II) are higher than those in the Thai and Mexican hemps, but lower than the R values of the Kompolt and Spanish hemps. In the Mexican and Thai hemps the length of the internode is nearly identical in the vegetative and generative parts, while in the other four types examined the internodes are considerably longer in the vegetative than in the generative part (Table 10). All six hemp varieties have nearly the same length of internode in the generative part, while differences in the length of internode in the vegetative part suggest that the two Turkish hemps as well as the Spanish and Kompolt hemp supply a larger volume of better quality fibre than the Mexican and Thai hemps.

Table 10

Number of nodes and length of internodes (cm)

Variety	Sex	Vegetative part				Generative part			
		number of nodes		length of internodes		number of nodes		length of internodes	
		1977	1978	1977	1978	1977	1978	1977	1978
Mexican	male	10.8	12.8	5.2	5.1	33.4	42.6	4.8	4.3
	female	3.2	3.2	5.4	5.1	26.2	41.6	5.1	4.9
Thai	male	12.4	16.4	6.1	5.8	14.8	22.0	6.0	5.5
	female	15.0	16.4	4.7	5.3	15.8	22.0	5.0	4.9
Spanish	male	11.0	10.4	16.1	15.9	6.2	6.2	4.3	4.6
	female	17.8	17.6	12.2	9.6	10.8	9.4	4.6	4.1
Kompolt	male	22.6	20.0	11.8	14.9	12.6	12.6	3.9	3.7
	female	16.6	14.8	14.5	18.1	7.6	8.4	4.8	4.7
Turkish I	male	—	12.0	—	15.3	—	12.4	—	4.8
	female	—	8.6	—	20.7	—	10.0	—	4.0
Turkish II	male	—	15.4	—	16.3	—	14.4	—	3.7
	female	—	12.6	—	13.0	—	13.2	—	2.9

Table 11

Variance analysis of internode length in hemp

Factor	FG	MQ	F	Significance
Variety (V)	3	219.872	128.535	++
Sex (S)	1	3.906	2.284	n.s.
Year (Y)	1	1.056	0.617	n.s.
Vegetative-Generative (V/G)	1	1019.090	595.752	++
Interaction (V)×(S)	3	36.629	21.413	++
Interaction (V)×(Y)	3	12.235	7.153	++
Interaction (V)×(V/G)	3	306.572	179.220	++
Interaction (S)×(Y)	1	0.256	0.150	n.s.
Interaction (S)×(V/G)	1	6.399	3.741	n.s.
Interaction (Y)×(V/G)	1	6.400	3.742	n.s.
Interaction (V)×(S)×(Y)	3	0.992	0.580	n.s.
Interaction (V)×(S)×(V/G)	3	21.952	12.833	++
Interaction (V)×(Y)×(V/G)	3	8.081	4.724	++
Interaction (S)×(Y)×(V/G)	1	0.073	0.043	n.s.
Interaction (V)×(S)×(Y)×(V/G)	3	2.257	1.320	n.s.

Table 12

Effects of variety and ratio of vegetative to generative part on the length of internode

Comparison of varieties for the length of internode

	Kompolt $\bar{x} = 9.55$	Spanish $\bar{x} = 8.93$	Thai $\bar{x} = 5.41$
Mexican $\bar{x} = 5.41$	4.54^{++}	3.92^{++}	0.40
Thai $\bar{x} = 5.41$	4.14^{++}	3.52^{++}	
Spanish $\bar{x} = 8.93$	0.62		

$LSD_{5\%} = 0.83$
$LSD_{1\%} = 1.00$

Lengths of internodes in the vegetative and generative parts
Vegetative — Generative $= 5.05^{++}$
$\bar{x} = 9.75$ $\bar{x} = 4.70$

$LSD_{5\%} = 0.41$
$LSD_{1\%} = 0.54$

On the basis of the variance analysis it can be established that the length of internode is not influenced by either the sex of the plant or the year (Table 11). The lengths of internodes in the vegetative parts of plants show significant differences between the varieties. In the Mexican and Thai hemps the internodes of the vegetative part are significantly shorter than in the other local varieties (Tables 12, 13, 14).

Table 13

Lengths of internodes in a comparison between variety and year, variety and vegetative-generative parts, and variety and sex

Interaction between variety and year (V)×(Y)

	1977	1978
Mexican	5.09	4.93
Thai	5.47	5.37
Spanish	9.30	8.56
Kompolt	8.73	10.36

$LSD_{5\%} = 1.79$
$LSD_{1\%} = 2.17$

Interaction between variety and vegetative-generative parts

	Vegetative	Generative
Mexican	5.24	4.78
Thai	5.46	5.36
Spanish	13.47	4.39
Kompolt	14.82	4.27

$LSD_{5\%} = 1.79$
$LSD_{1\%} = 2.17$

Interaction between variety and sex

	Male	Female
Mexican	4.85	5.17
Thai	5.87	4.95
Spanish	10.22	7.64
Kompolt	8.58	10.52

$LSD_{5\%} = 1.79$
$LSD_{1\%} = 2.17$

Table 14

Variance analysis of shoot length in hemp

Factor	FG	MQ	F	Significance
Variety (V)	3	55,111.24	175.519	++
Sex (S)	1	4,757.94	15.153	++
Year (Y)	1	5,035.05	16.036	++
Interaction (V)×(S)	3	6,885.15	21.928	++
Interaction (V)×(Y)	3	8,596.99	27.380	++
Interaction (S)×(Y)	1	83.29	0.265	n.s.
Interaction (V)×(S)×(Y)	3	114.06	0.363	n.s.

There is a general tendency for the proportion of leaves to decrease and that of the stem to increase during ontogeny, while that of the root remains more or less constant or may rise slightly by the end of ontogeny (Figs 5, 6). In the Mexican and Thai hemps the stem made up 50—60% of the total weight of the plant at the end of the vegetation period in 1977 and 45—50% in 1978; in the Spanish, Kompolt and Turkish I varieties this value was above 60% in both years. In the male plants the stem represents a larger proportion of the total

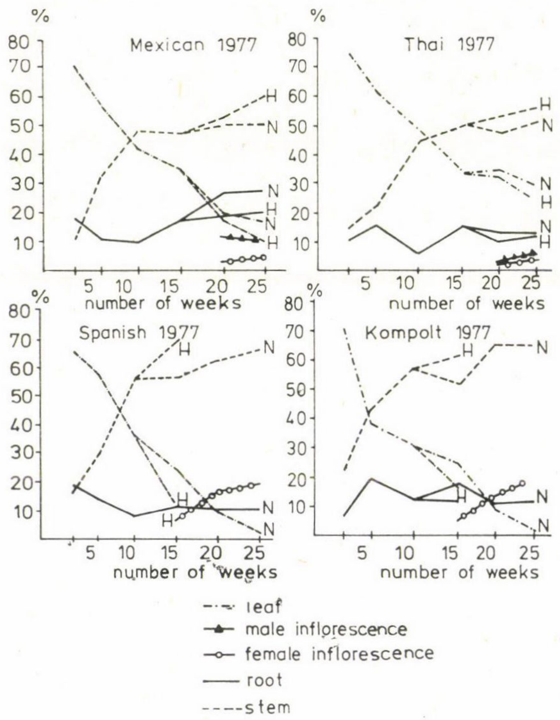

Fig. 5. Changes in the percentage fresh weight of hemp during ontogeny (1977)

plant weight than in the female plants. The difference is the greatest in the case of the Turkish II hemp, where the stem makes up 63% of the total plant weight in male and 52% in female plants.

The proportion of leaves is in inverse correlation with the stem. This value is 10—20% for the Mexican and Turkish II hemps, 25—30% for the Thai hemp and below 10% for the

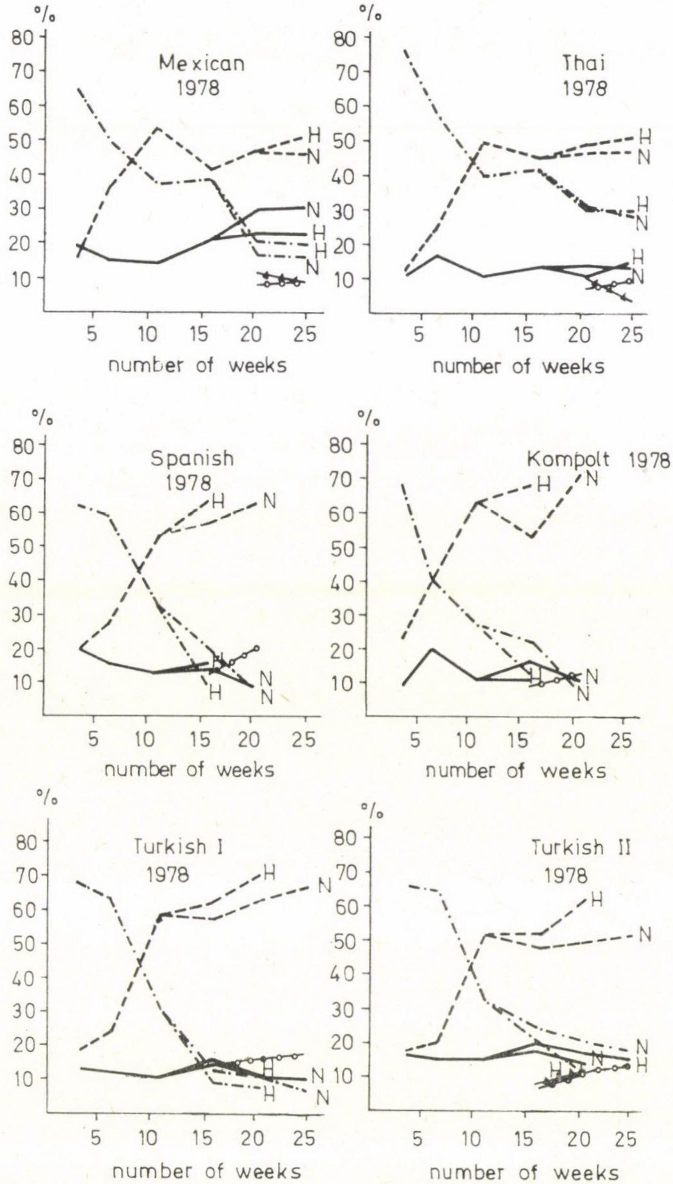

Fig. 6. Changes in the percentage fresh weight of hemp during ontogeny

other hemp varieties. It is remarkable that the proportion of stem in the Kompolt hemp reaches the proportion of the leaves much earlier than in the other local varieties. The percentage of leaves is generally higher in the female than in the male plants, with the single exception of the Mexican hemp, where in 1978 the leaves represented a higher percentage of the total plant weight in the male than in the female plants. The percentage of roots at the end of the vegetation period was the same as or slightly higher than that of the leaves, except in the Thai hemp where it was lower. The root makes up 10—20% of the total plant weight in general, and 20—30% in the Mexican hemp.

The proportion of the inflorescence ranges from 5 to 10%. This proportion shows an increasing tendency during the vegetation period in female plants and — with the exception of the Thai hemp in 1977 and the Turkish II type — a decreasing tendency in male plants. In the Mexican hemp in both years, and in the Thai variety in 1977, the percentage of the inflorescence was higher in male than in female plants. In other cases the inflorescence of female plants makes up a higher percentage of the total plant weight.

The proportion of inflorescence in the Mexican, Thai and Spanish male plants in 1977, and in the Kompolt variety in both years, was below 10%, while in the other cases it ranged between 10 and 20%. Inflorescence made up the highest proportion of the total plant weight in the female Spanish hemp: 20% in both years.

According to the generally accepted taxonomy of Sizov—Serebiakov (1940) there are only 4 geographical hemp races: 1) proles borealis, 2) proles australis, 3) proles medioruthemica and 4) proles asiatica.

According to the above classification the Hungarian (control), Southern European, Central and South American varieties belong to the southern or australis race. The northern hemps, including the Russian ones, belong to the medioruthemica race. The borealis and asiatica races are not important in Europe (personal communication from Bócsa).

The types of hemp examined originated from various geographical places and showed two different forms of behaviour: the Spanish, the two Turkish and the Hungarian hemps seem to belong to the same geographical race, as their behaviour is nearly identical, while the Mexican and Thai hemps represent another type. Since the plant data are contradictory and do not entirely agree with the classification given by the Soviet authors the question requires further investigation.

However, according to the morphological and phenological data it is almost certain that two different types of proles are concerned here, so studies on the psychotropic substances contained in them promise to be highly interesting.

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THE ROLE OF TITANIUM IN PLANT LIFE. III. INTERACTION BETWEEN TITANIUM AND DIKONIRT

One of the important tasks of plant protection is the control of weeds. Dikonirt, a herbicide containing 70—76% of the sodium salt of 2,4-dichlorophenoxy-acetic acid as active agent has long since been efficiently used against dicotyledonous weeds in cereals, rice, maize and grasslands, which are very important crops in Hungary. This herbicide has recently been the subject of increasing concern, as the danger of the chemicals being dispersed has become greater now that plant protection by aircraft is gaining ground in Hungarian agriculture. Investigations aimed at protecting dicotyledonous crops against damage produced by spray-

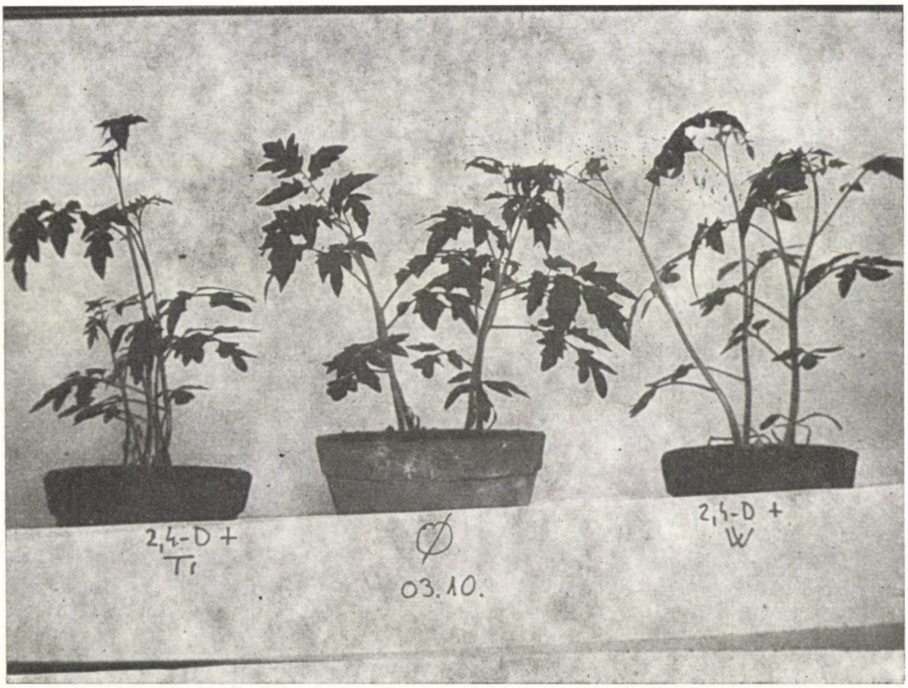

Fig. 1. Tomato plants, raised under laboratory conditions, at the age of 40 days. Plants marked 2,4-D + Ti were sprayed with Dikonirt solution at the cotyledon stage, then with titanium chelate solution. Plants marked 2,4-D + W were sprayed with Wuxal solution instead of titanium chelate

Fig. 2. Tomato plants grown under field conditions in small plots. On the right, plants sprayed only with Dikonirt solution; on the left, those sprayed with titanium chelate on two occasions after the Dikonirt treatment

ing in neighbouring fields have therefore assumed increasing importance. Within the framework of this antidote research the authors have studied the effect of titanium, a microelement which has proved highly efficient in many other experiments (PAIS 1974, PAIS *et al.* 1977a, PAIS *et al.* 1977b, PAIS *et al.* 1978). According to the concept developed by PAIS—FEHÉR (1977), titanium chelate gives protection against biochemical disorders when it is supplied early, and helps recovery if applied after the damage has been done.

As previously mentioned, Dikonirt which is used for weed control in cereals and maize may cause serious damage in important dicotyledonous crops like tomato, paprika and grapes. LEHOCZKY (1974) and TERPÓ—TERPÓ-POMOGYI (1975) analysed the adverse effect of Dikonirt on grapes. The harmful effect of the herbicide is also discussed by HAROUN (1973), who studied its decomposition as well.

Several authors (WORT 1964) obtained good results by supplying the plants with various microelements in order to compensate for the effect of 2,4-D. By combining the herbicide with fertilizers containing microelements, a considerable yield increase was achieved in dwarf bean in addition to full protection of the host plant. Good results were also attained in maize with a simultaneous, very successful destruction of weeds. In the German Democratic Republic a herbicide containing 2,4-D combined with copper is manufactured under the trade name "Woldusin"; this can be efficiently used in cereals and on pastures (LEHMANN 1976).

In preliminary experiments the protective and compensatory effects of titanium chelate produced in the laboratory of the Chemistry Department at the University of Horticulture, Budapest were studied in comparison to the commercial product Wuxal, which contains different macro- and micro-elements, on tomato and marrow plants treated with Dikonirt under laboratory conditions.

The experimental plants were kept in pots and the treatment was carried out in the following way: at the cotyledon stage half the plantlets were sprayed with 3 ml/plant Dikonirt solution at a concentration of 50 mg/l, and the other half with 8 ml/plant 1% Wuxal solution or 10 ppm titanium-containing chelate solution. (The titanium chelate is an organic metal complex patented by Pais—Fehér.) After three days the treatments were interchanged. The effects of the treatments were evaluated by phenological observation 34 days later, and coloured photos were taken of the experimental plants.

The marrow test plants showed hypertrophy in response to Dikonirt applied after spraying with titanium solution, though the hypertrophy was of a lesser degree than in the Wuxal treatment. Titanium supplied after the Dikonirt treatment resulted in a lower degree of deformation, again compared with the Wuxal treatment. Plants given Dikonirt alone showed strong hypertrophy even in the young leaves.

When tomato was used as the test plant the observations led to similar results. Experience showed that tomato was the better test plant, so this was the only test plant used when repeating the experiment. The plants were first given a Dikonirt treatment with a concentration of 50 mg/l, then on two occasions (on the 3rd and 12th day) foliar nutrition was carried out with 10 mg/l chelate solution containing titanium or 1% Wuxal solution. In the former case the plants only showed a low degree of hypertrophy and produced healthy fruits. This was not observed in plants given Dikonirt treatment, and the flowers were not fertilized. Slight improvement was also seen under the influence of Wuxal, but this was negligible com-

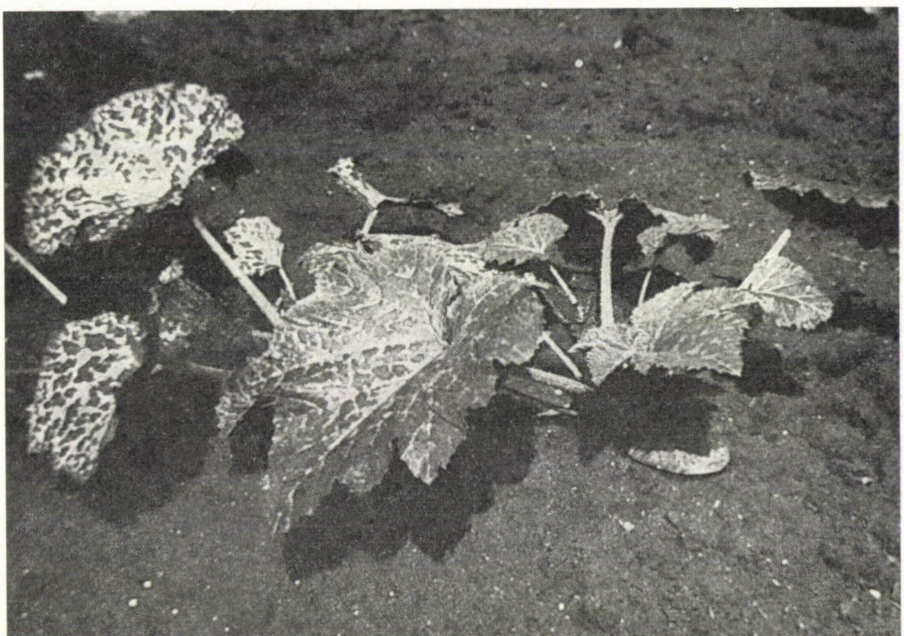

Fig. 3. Lesions on the leaves of "Runnerless white" marrow plants grown in the field and sprayed with titanium solution twice after the Dikonirt treatment

pared to the effect of titanium (Fig. 1). It should be mentioned here that in the first experiments, unlike the subsequent ones, the chelate solution was not used as a separate control. Using a chelate solution of the same concentration no protective effect was observed, so the effect must be due exclusively to titanium.

In the subsequent experiment only the titanium solution was used for foliar nutrition and the test plants were Soroksári Korai tomato seedlings raised in the greenhouse. At the foliage-leaf stage each plant was sprayed with 2 ml Dikonirt solution at a concentration of 100 mg/l, then some of them were treated with titanium solution 1, 3, 6 or 8 days after the herbicide application. Below, the results of phenological observations made on the 40th and 50th day after spraying are presented.

At the first observation the best result was found with titanium treatment applied on the first or third day. Although, some cellular proliferation was seen on the stems of the plants, and the flower-buds were deformed in one of them, the extent of deformation was greater after spraying on the sixth or eighth day: the upper parts of the stems were curved and the leaves were divided. Plants given Dikonirt by itself showed a still more intensive deformation and produced no flowers or fruit.

During the second survey 10 days later, plants treated only with Dikonirt were deformed and showed cellular proliferation; neither flowers nor fruit were found on them. Some of the plants given titanium solution 1 day after the Dikonirt treatment produced flowers and fruit, but apart from a slight curvature on the stem of one of them, no substantial change was found in these plants. As a result of titanium treatment after 3 days the plants "outgrew" the earlier lesions and most of them produced healthy flowers and fruit. Titanium solution applied after 6 days also has a favourable effect: some flowers and fruit were produced. Plants

Fig. 4. "Pannónia Kincse" table grape plants sprayed with Dikonirt

Fig. 5. "Pannónia Kincse" table grape plants given foliar nutrition with titanium chelate on two occasions after the Dikonirt treatment

given titanium treatment after 8 days presented the worst picture: the plants became stunted and bent, and the flower-buds were not healthy.

Field experiments were subsequently set up with 4 horticultural plants: tomato, marrow, paprika and grapes. The vegetable plants were treated with 3 ml/plant Dikonirt solution with a concentration of 50 mg/l at the three-leaf stage; the grapes were sprayed with 250 ml/plant of the same solution. On the 6th and 12th day after the herbicide treatment some of the plants were sprayed with a solution containing 10 mg/l titanium, equal in volume to the herbicide solution.

When paprika (Soroksári fehér) was used as the test plant, specimens treated with Dikonirt became stunted, with short shoots. Although they produced fruits, the latter were very small and immature compared to the control. As a response to titanium applied after the herbicide treatment the plants showed a growth habit identical to that of the control and developed many flowers and healthy, attractive fruits.

The tomato test plants (K-III) were totally destroyed by the Dikonirt treatment (Fig. 2). Plants later given titanium treatment produced a satisfactory number of well-developed fruit; at the worst the proportion of ripe fruit was somewhat smaller than in the control.

The marrow (Runnerless white) test plants given herbicide treatment developed a poor foliage, and the few small fruits produced rotted in a short time. Plants later treated with titanium solution were slightly underdeveloped compared to the control (Fig. 3), and the normally developed fruit did not ripen at the correct time either.

The grape test plants (Pannónia Kincse) produced highly hypertrophic shoots in response to the Dikonirt treatment; the leaves were curled up and fell early (Fig. 4), and fruit setting was hardly 15% of that in the control. Plants later treated with titanium solution were somewhat underdeveloped and the leaves showed teratological changes (Fig. 5), but the fruit yield was hardly less than in the control.

In the case of the three vegetable plants, the ripe seeds were removed from the experimental plants and subjected to a germination test. The seeds of Dikonirt-treated plants were totally incapable of germinating, while those of plants later treated with titanium solution showed practically the same germinative ability (over 80% on average) as the seeds of the control plants. In the case of grapes the fruit was subjected to analysis: plants later treated with titanium solution gave an intermediate value between that of the control and that of plants treated exclusively with Dikonirt as regards the sugar content of the fruit.

On the basis of the favourable experience gained so far, new experiments have been set up with widely-used herbicides containing s-triazine as active agent, using various economically important test plants (spring barley, wheat, tomato), in order to acquire a deeper knowledge of the antidote effect of foliar nutrition with titanium solution, and of the parameters of the most favourable application.

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EXPERIMENTS AIMED AT PRODUCING HYBRID ALFALFA. II. PRODUCTIVITY OF HYBRID COMBINATIONS

If the yield of alfalfa is to increase, varieties with higher yield potential will be needed, as well as a higher standard of other agrotechnical factors. It is essential for the lines and clones used to produce new varieties to have broad genetic backgrounds, good general combining abilities and resistance to those microorganisms and insects which adversely influence the quantity and quality of yield. In hybrid alfalfa breeding greater care must be taken in choosing the partners than in the case of synthetic varieties, since the possibility of selection is more limited. The situation is particularly difficult with sterile mother plants, because it takes a great deal of time and effort to find them, and even in exceptional cases the breeder only has a few pollen-sterile clones at his disposal.

On the other hand, hybrid alfalfa has the advantage that almost exclusive cross-pollination can be expected, so the heterosis effect will be more pronounced.

Most breeders produce alfalfa hybrids after the classical pattern:

A (ms) × B

AB (ms) × C

ABC hybrid.

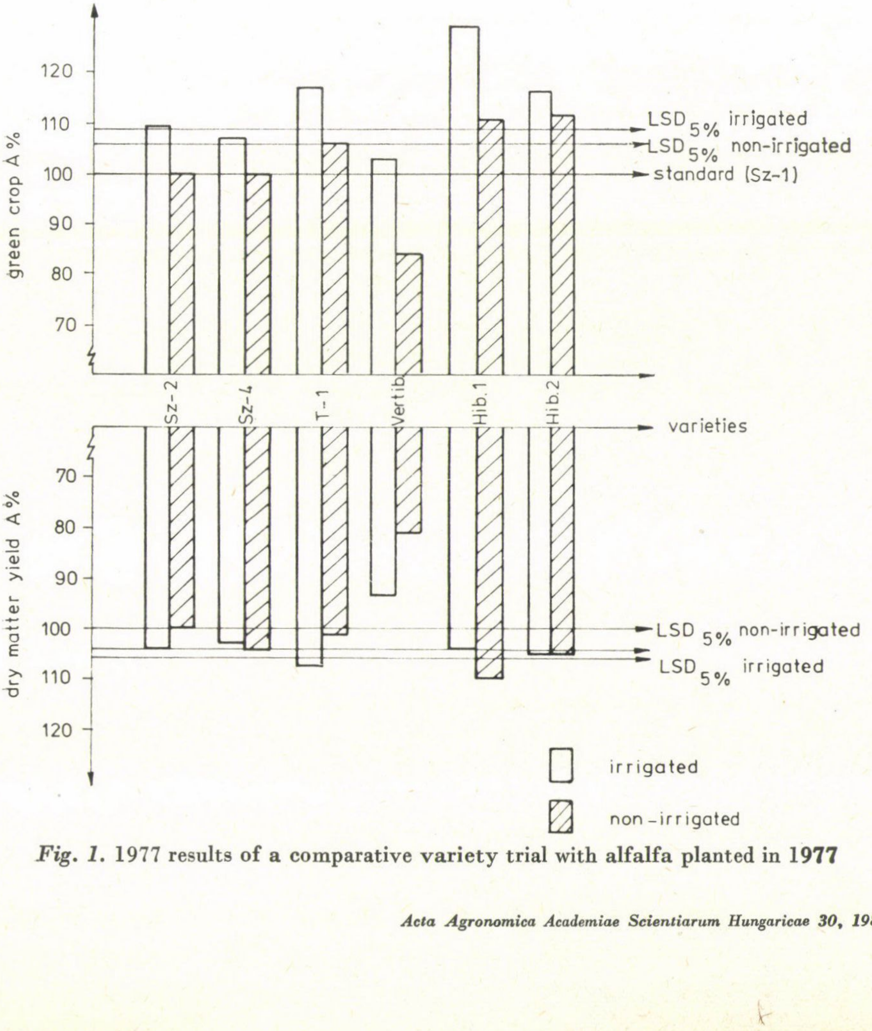

Fig. 1. 1977 results of a comparative variety trial with alfalfa planted in 1977

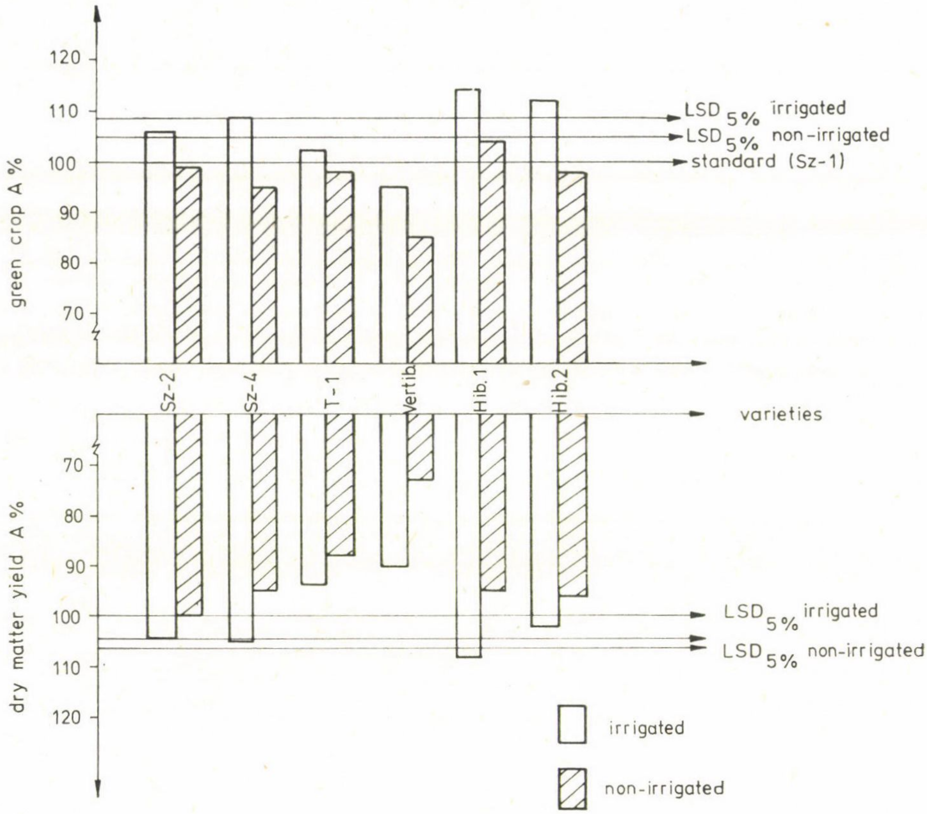

Fig. 2. 1978 results of a comparative variety trial with alfalfa planted in 1977

On the basis of the comprehensive work of CHILDERS—BARNES (1972) a number of authors have achieved particularly important results and done pioneer work in this field in the United States of America, while in the Soviet Union the research results of VENGRENOVSKY—TERESHCHENKO (1969) are the most significant.

All breeders use male sterile mother plants as initial material. As the B partner, to maintain the sterility, a plant chosen from an inbred line or variety should be used, which will provide an 88—100% sterile F_1 generation after crossing with the A mother plant (TERESHCHENKO 1970).

While there are certain constraints in choosing the A and B partners (sterility, ability to fix the sterility), in the case of partner C valuable agronomical characters should primarily be taken into consideration. With a view to satisfactory seed production it is an advantage of the third line is an abundant pollen producer. There is a close positive correlation between the amount of pollen and the seed production in the F_1 generation (BARNES *et al.* 1974).

The possibilities of hybrid alfalfa breeding are not fully known as yet. Many tasks must be solved before deciding whether hybridization can be used in alfalfa breeding, and at what price higher productivity can be achieved (CHILDERS—BARNES 1972).

In advance of many other European countries, BŐJTÖS (1971) began looking for and selecting the basic material required for hybrid alfalfa breeding in Hungary and started hybrid breeding. In a variety trial he compared the productivity of the hybrids to that of three control varieties (Mv-Synalfa, Szarvasi-1, Tápiószelei-1) and found the first-year yields

Fig. 3. Comparative trial on alfalfa varieties

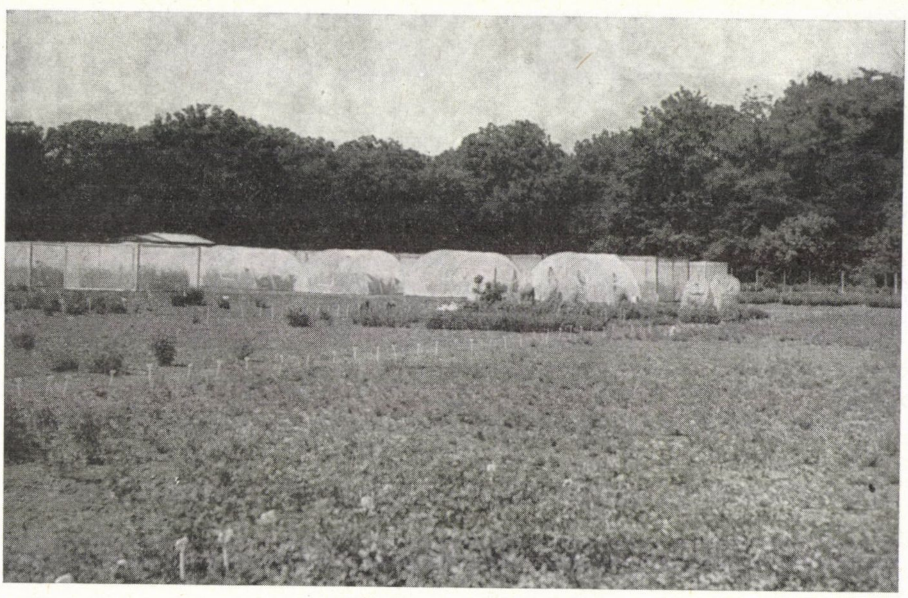

Fig. 4. Production of F_1 and hybrid in isolation cages

Table 1

Green crop in a comparative variety trial with alfalfa planted in 1976

Variety	Total green crop in 1976—1977		Variety	Green crop in 1977	
	q/ha	A%		q/ha	A%
Szarvasi impr. var.	1226	117	Hybrid 111	988	116
Hybrid 37	1199	115	Hybrid 105	983	116
Szarvasi impr. var.	1189	114	Szarvasi impr. var.	979	115
Szarvasi 2	1170	112	Hybrid 104	970	114
Hybrid 111	1152	110	Hybrid 106	960	113
Hybrid 104	1141	109	Hybrid 36	959	113
Hybrid 105	1139	109	Hybrid 109	935	110
Hybrid 106	1118	107	Hybrid 37	932	110
Hybrid 36	1117	107	Szarvasi 2	920	108
Hybrid 32	1110	106	Hybrid 107	900	106
Hybrid 109	1106	106	Szarvasi impr. var.	896	105
Hybrid 34	1088	104	Hybrid 24	893	105
Hybrid 107	1071	102	Hybrid 110	893	105
Hybrid 108	1056	101	Hybrid 108	888	104
Hybrid 24	1052	101	Szarvasi 1	875	103
Hybrid 110	1043	100	Nagyszénási	870	102
Tápiószelei 1 St	1043	100	Mv Synalfa	863	102
			Hybrid 28	960	101
Mv Synalfa	1039	99	Hybrid 25	852	100
Szarvasi 1	1008	97	Hybrid 27	852	100
Hybrid 28	1008	96	Tápiószelei 1 St	850	100
Nagyszénási	995	95			
Hybrid 27	994	95	Hybrid 32	844	99
Hybrid 33	986	94	Hybrid 34	843	99
Hybrid 26	967	92	Hybrid 30	823	97
Hybrid 103	955	91	Hybrid 26	821	97
Hybrid 35	951	91	Hybrid 31	804	95
Hybrid 30	943	90	Hybrid 29	803	94
Europe	943	90	Hybrid 22	796	94
Hybrid 22	941	90	Europe	793	93
Hybrid 31	934	89	Hybrid 35	779	91
Hybrid 29	931	89	Au-Px Syn. 1	769	90
Hybrid 23	888	85	Hybrid 103	767	90
Hybrid 25	984	94	Hybrid 33	764	90
Au-Px Syn. 1	871	83	Vertibenda	756	89
Vertibenda	868	83	Hybrid 23	752	88
Vertus	849	81	Vertus	738	87
Verko	841	80	Verko	728	86
$LSD_{5\%}$	67	6.4		76	9

of 13 hybrids to be significantly (10—18%) higher than the average of the three standards (Bőjtös 1973).

According to the results obtained in another experiment by evaluating the yield in a large number of hybrid combinations, 50% of the latter produced larger yields than the synthetic varieties. Hybrids made up of partners with high combining ability and a broad genetic background were found to be particularly good (Bőjtös 1976). An account has already been given in this journal of the first results of the alfalfa hybrid breeding carried out at the Irrigation Research Institute, Szarvas (Izsáki *et al.* 1977).

While the search for A and B partners suitable for producing hybrids was being carried out in the period between 1971 and 1977, in recent years emphasis has been placed on the

Table 2

Dry matter yield in a comparative variety trial with alfalfa planted in 1976

Variety	Total dry matter yield in 1976—77		Variety	Dry matter yield in 1977	
	q/ha	A%		q/ha	A%
Szarvasi impr. var.	267	124	Hybrid 105	222	126
Hybrid 32	265	125	Hybrid 111	221	125
Szarvasi impr. var.	263	122	Hybrid 104	215	122
Hybrid 37	271	121	Hybrid 106	214	121
Hybrid 111	258	119	Hybrid 36	213	121
Hybrid 105	257	119	Szarvasi impr. var.	210	119
Szarvasi 2	257	119	Habrid 37	203	115
Hybrid 104	253	117	Hybrid 109	203	115
Hybrid 105	249	115	Szarvasi 2	202	115
Hybrid 36	248	115	Hybrid 107	202	114
Hybrid 107	241	111	Szarvasi impr. var.	201	114
Hybrid 109	240	111	Hybrid 32	201	114
Hybrid 108	239	111	Hybrid 108	201	114
Mv Synalfa	239	110	Mv Synalfa	198	113
Hybrid 34	234	109	Hybrid 110	196	111
Hybrid 24	230	106	Hybrid 24	195	111
Hybrid 110	229	106	Nagyszénási	193	110
Nagyszénási	221	102	Hybrid 25	189	107
Hybrid 25	219	101	Hybrid 27	187	106
Hybrid 27	218	101	Hybrid 28	184	105
Tápiószelei 1 St	216	100	Hybrid 30	183	104
			Hybrid 34	183	104
Hybrid 28	216	100	Szarvasi 1	182	103
Hybrid 33	216	100	Hybrid 31	178	101
Szarvasi 1	210	97	Tápiószelei 1 St	176	100
Hybrid 30	210	97			
Hybrid 26	207	96	Hybrid 26	176	100
Hybrid 31	207	96	Europe	173	98
Hybrid 103	207	96	Hybrid 22	172	98
Europe	206	95	Verko	171	97
Hybrid 35	205	95	Au-Px Syn. 1	169	96
Hybrid 22	204	94	Hybrid 29	169	96
Verko	198	92	Hybrid 35	168	95
Hybrid 29	196	91	Hybrid 33	167	95
Vertibenda	192	89	Vertibenda	167	95
Au-Px Syn. 1	191	88	Hybrid 103	166	94
Hybrid 23	184	85	Vertus	158	90
Vertus	182	84	Hybrid 23	156	89
$LSD_{5\%}$	18	8.3		22	13

selection of C partners, the examination of their combining ability, and the inoculation of B and C lines with *Fusarium* and *Verticillium albo-atrum* in several cycles, followed by testing and selection.

Since a sterile clone produces adequately sterile F_1 progeny with more than one B partner, there is a certain, though limited, possibility of selecting the sterility-maintaining B partners for resistance and other agronomical properties too. With a view to broadening the genetic background, last year hybrids were produced in which the second partner was formed jointly by clones derived from five varieties of different geographical origin.

The line or variety to be used as the C partner must possess all the agronomical, morphological and physiological properties set as objectives in producing the hybrid. The most suitable C partners were chosen from several hundreds of inbred lines, varieties and clones, according to the criteria mentioned above. The productivity, habit and earliness of the hybrid can be considerably influenced by choosing the right C partner. Also, the C partner has an important role in increasing the resistance level of the hybrid.

The resistance level of the hybrid is greatly influenced by the resistance of the C partner. If the third parent is synthesized from several lines, the genetic variation will be greater.

The production of F_1s and hybrids is carried out on isolated sites, or, if there is a smaller amount of stock, cross-pollination takes place in tulle tents with the help of bees (Fig. 1).

The hybrids produced were included in a pilot experiment with a number of registered Hungarian varieties, experimental hybrids and several foreign varieties (Fig. 2).

In a comparative variety trial planted in 1974 and 1976 the preliminary examination of 48 hybrid combinations was carried out. On the basis of the results of the pilot experiments the best hybrid combinations have been further evaluated since 1977 in irrigated and non-irrigated treatments at Szarvas and in trials set up without irrigation in Tolna and Komárom counties.

The pilot hybrid experiments were carried out in 5 m^2 plots arranged in a random block design with three replications. The comparative variety trial in 1977 was laid out in a random block design with three replications, in 10 m^2 plots with irrigated and non-irrigated treatments.

The results of the trial planted in 1976 are summarized in Tables 1 and 2.

The data in the tables show that the hybrids differ from one another in productivity. These differences can be explained primarily by the different productivity and combining ability of the B and C partners. For the sake of comparison varieties and experimental hybrids from Szarvas and Kompolt were used, as well as some excellent Western-European varieties.

As can be seen from the data, some of the hybrids produced were higher yielding than even the best synthetic varieties. This tendency suggests that if the parent partners are properly chosen the productivity of the hybrids could be increased still further.

The results of comparative variety trials set up in 1977 are presented in Figs 3 and 4 by giving the first- and second-year green crop and dry matter yield of some Hungarian alfalfa varieties and hybrids. The variety Szarvasi-1 was taken as the standard, since the aim is to produce hybrids which will outyield Sz-1 under local conditions.

The results are given as relative values.

The figures reveal that all the varieties responded to irrigation with surplus yields, which were exhibited mainly in the green crops of the two years.

Comparing the yields of the two years it is found that the variety T-1, which gave an outstanding result in the first year, fell behind in the second year owing to its low resistance level. In the third and possibly fourth years the yield differences change in favour of the resistant varieties and hybrids.

*

Prepared at the Irrigation Research Institute, Szarvas.

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ANALYSIS OF THE MORPHOLOGICAL CHARACTERISTICS OF THE PANICLE IN FOUR POPULATIONS OF SORGHUM HALEPENSE (L.) PERS.

It is a much discussed question among Hungarian florists and plant protection experts whether the sudden wide distribution of *Sorghum halepense* (L.) Pers. and the serious damage it causes can be explained by the evolution of ecotypes. While Sárkány (1973) mentions the possibility of local ecotypes having come into existence, Ujvárosi (1976), (personal communication) does not think it likely.

The first step in clearing up the problem would be to discover which of the morphological and taxonomical properties characterizing the different *Sorghum halepense* populations show variations suitable for the differentiation of ecotypes.

Table 1

Collecting dates, and soil, precipitation and herbicide data for the growing sites

	Bácsalmás	Nagykovácsi	Zichyújfalu	Alag
Collecting date	14. 9. 76	16. 9. 76	15. 9. 76	17. 9. 76
Field number	16	exp. plot	55	V-2
Soil type	medium heavy loam	Ramann's brown forest soil	carbonate meadow chernozem	sandy loam
Arany's viscosity index	43	50	40	39
Humus content, %	3.54	9.37	3.36	1.5
pH in water	7.6	7.5	8.1	7.8
Type and rate of herbicide	—	none	Nitanil II. 10.5 kg/ha	Trikomb 8 kg/ha
Date of herbicide application	—	none	21 April	3 May
Precipitation, mm				
May 1976	41.5	24.5	28.3	21
June 1976	41.1	35.5	35.1	31.1
July 1976	23.1	63.6	73	48.7
August 1976	29.9	19.2	26.2	17.7
September 1976	50.7	142	96.7	116.7

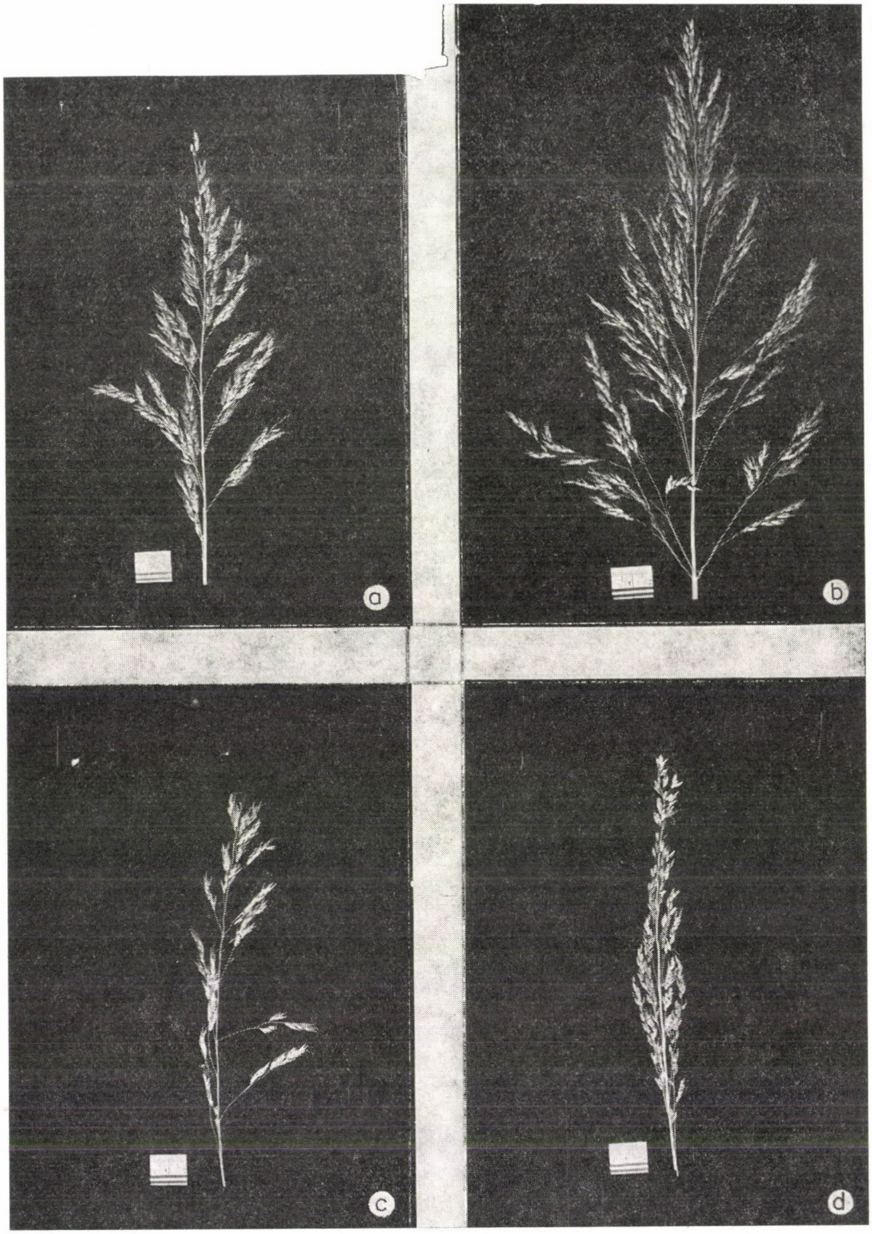

Fig. 1. Photo of representative panicles chosen from the four populations [*a)* Bácsalmás, *b)* Nagykovácsi, *c)* Zichyújfalu, *d)* Alag]

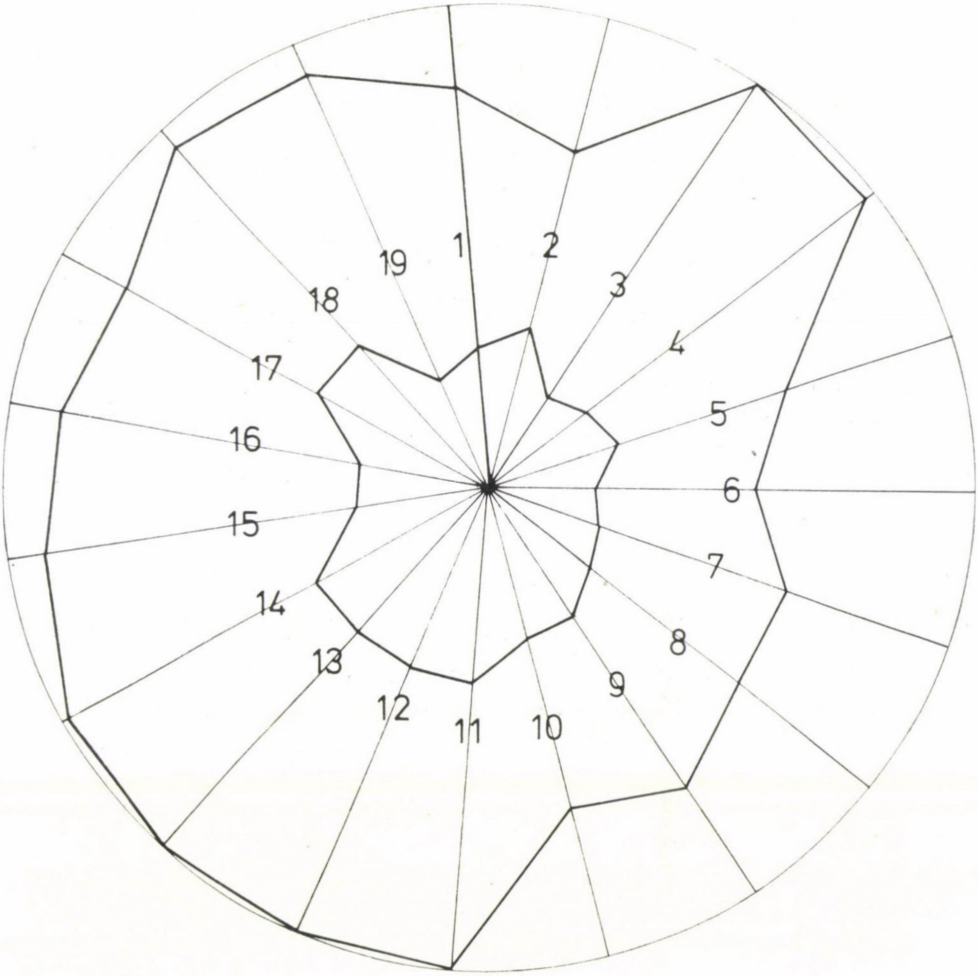

Fig. 2a

The analysis of the populations was carried out by taking morphological measurements on harvested, pressed panicles and their spikelets. It was on the basis of literary data that the panicle was chosen to characterize the plant. The differences in panicles were successfully used by McWhorter (1971) in distinguishing the American ecotypes. In the morphological differentiation of *Sorghum cultivars* (Bányai 1968, 1977) the morphological features of the panicle are the usual distinctive characters. In the course of the analysis the characteristics of the grain were also considered. The four johnsongrass populations examined were collected at nearly the same time from four different sites. Those obtained from Bácsalmás, Zichyújfalu and Alag were grown in large-scale maize fields, while the population from Nagykovácsi was derived from a clone earlier collected in the Bácsalmás field and then grown on the trial grounds in Nagykovácsi. The collecting dates and the data of the sites, which were mostly extracted from the field registers, are contained in Table 1.

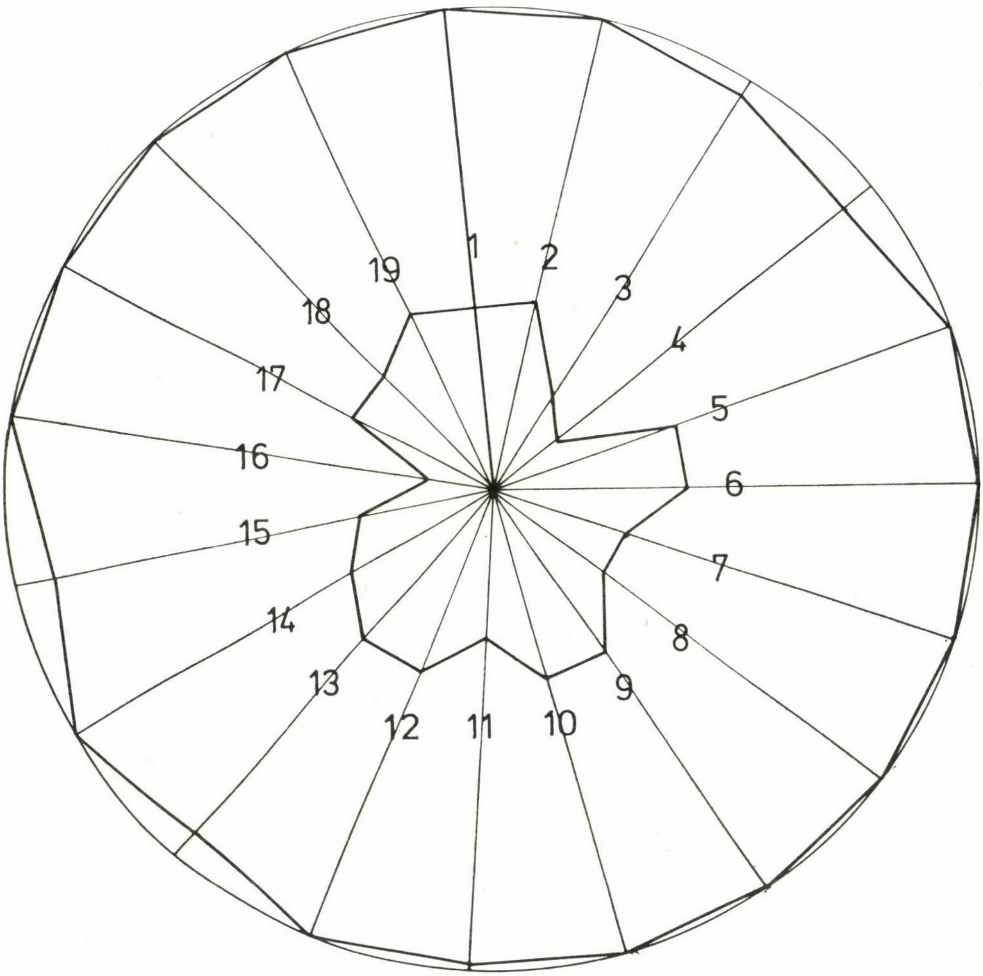

Fig. 2b

On the representative areas chosen, the johnsongrass panicles were collected along the two diagonals of a square with sides of about 100 paces each; this system of sample taking was used because of the patchy arrangement of the clones. Exceptions were the Alag field and the Nagykovácsi trial grounds, where the samples were taken from a much smaller area, though in a similar way. On the Nagykovácsi trial grounds the johnsongrass clone was grown in a root isolator, and other weed species were removed by hand weeding. The weed-plant coenoses of the Bácsalmás, Zichyújfalu and Alag fields and the extent of johnsongrass infestation were characterized by the coenological survey of 8 squares of 2×2 m each systematically arranged along the diagonal of the square with sides of 100×100 paces chosen as the sampling area. The frequency values obtained are shown in Table 2. According to the result of observations made on the sampling areas, johnsongrass is a plant with protracted seed ripening; stalks with highly diverse phenophases and panicle opening were found within the same clones

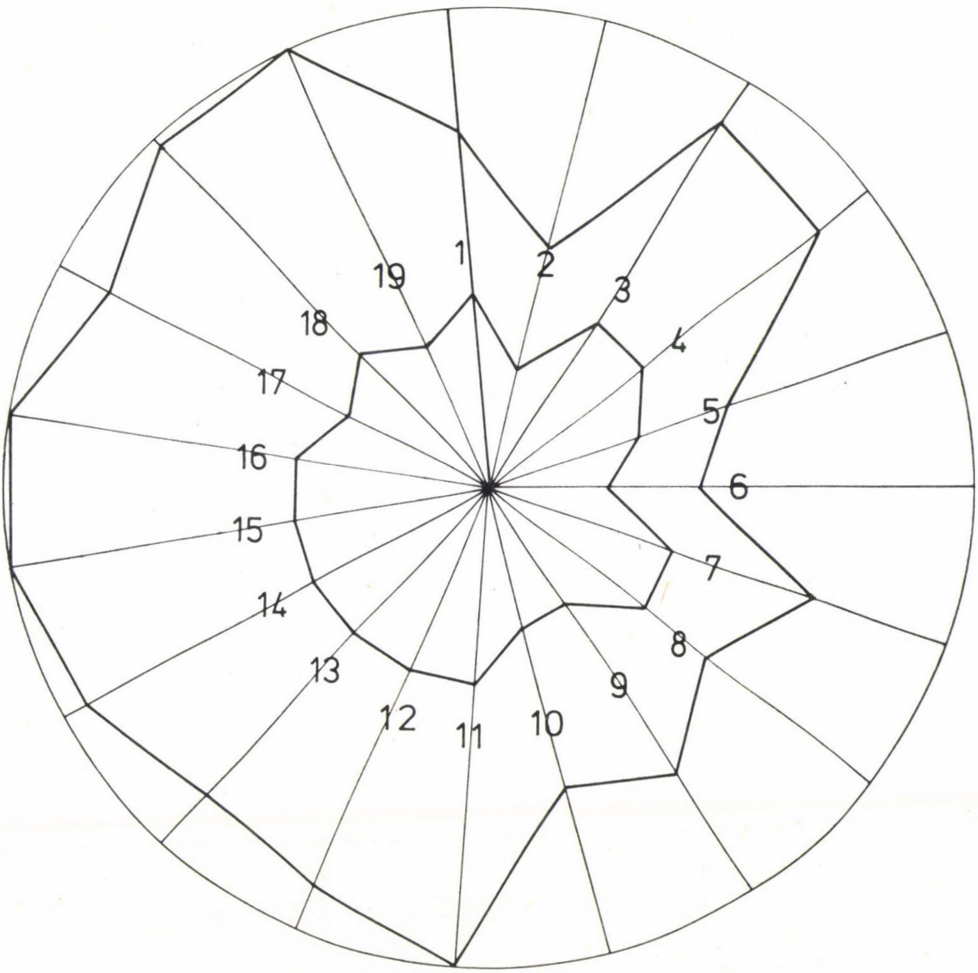

Fig. 2c

at the time of collecting. Since the investigation was aimed at studying the panicles of the populations, it was restricted to those phenophases in which the panicle could be examined with the method of external morphology. Unopened panicles and those which had obviously shed their grains were not included among those used for the analysis.

In order to have samples representing the respective populations as fully as possible, no arbitrary selection was made from the intermediate phenophases. Using the phenological scale originally elaborated for rice by the FAO (Walker, In: CHIARAPPA 1971), panicles from the phenological stage 5.5 to 6.9 were included in the range of analysis. The percentage distribution of 100 panicles per site among the different phenophases is seen in Table 3.

Morphological description of the johnsongrass panicle. The panicle of johnsongrass can be placed in type II./D./1 of ARMSTRONG's (1921) Gramineae inflorescence types, i.e. the panicle is loose, open and cracked, each spikelet has only one perfect flower. In accordance

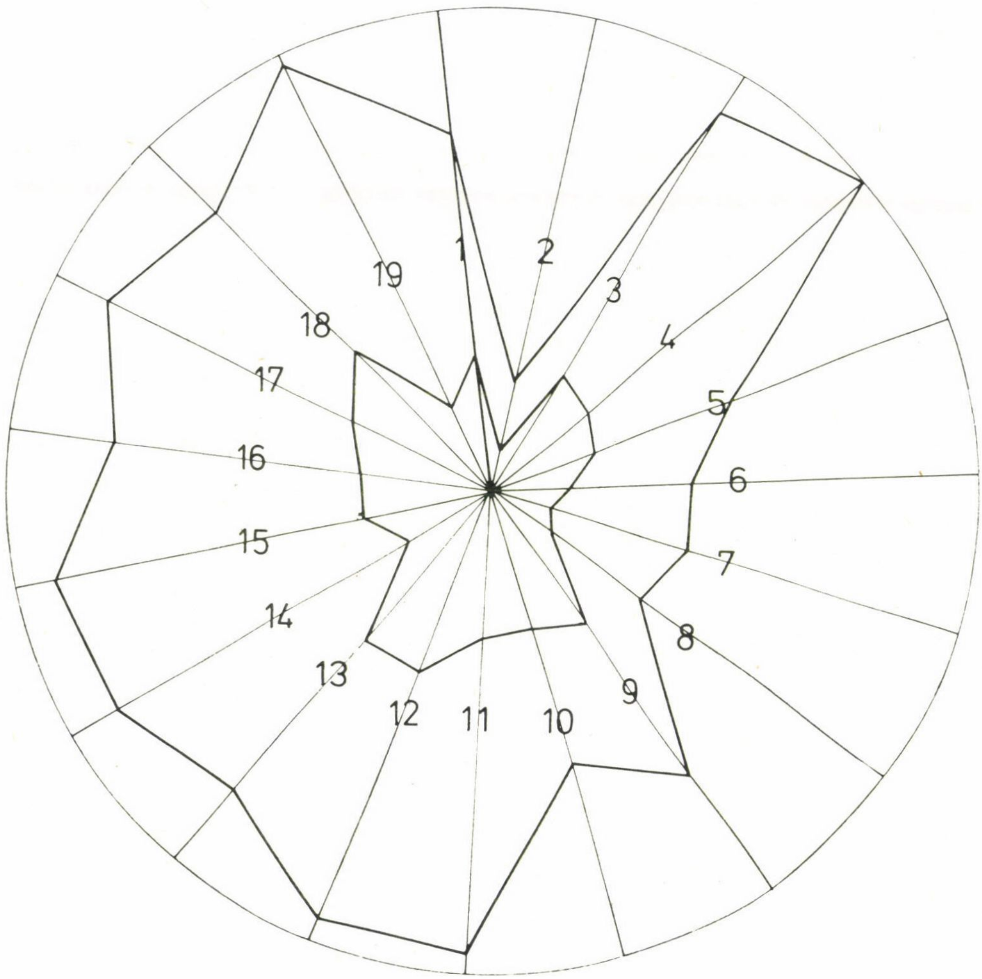

Fig. 2d

Fig. 2. Mean values and standard deviations of representative characters in the four populations as illustrated on polygons [*a)* Bácsalmás, *b)* Nagykovácsi, *c)* Zichyújfalu, *d)* Alag]. The outer polygon shows the arithmetic means, the inner one the standard deviation values

with the general type of the tribe Andropogoneae, the panicle of *Sorghum halepense* is of quadruple composition (Bews 1929). The double and triple spikelets form a spike, the spikes form a cluster, and the clusters are united in a panicle:

flower
——— spikelet
——— spike
——— cluster
——— panicle

According to HEGI (1936) the length of the panicle is 15—30 cm; HITCHCOCK (1951) describes the panicle as 15—50 cm long, while in Ghisa's work (in: SAVULESCU 1972) a panicle length of 20—25 cm is given. According to the panicle terminology applied to *Sorghum cultivars* (BÁNYAI 1968) the johnsongrass panicles examined correspond to the pointed ellipsoid, or to the spindle-shaped type. According to MCWHORTER (1971) in the panicles of the American

Table 2

Frequency distribution of weeds at the sites studied

Frequency	Bácsalmás	Agárd	Alag
76—100% occurrence	*Echinochloa crus-galli*	—	*Echinochloa crus-galli* *Setaria viridis*
51—75% occurrence	*Setaria viridis* *Sorghum halepense*	*Amaranthus retroflexus* *Setaria viridis*	*Amaranthus retroflexus*
26—50% occurrence	*Amaranthus retroflexus* *Amaranthus lividus* ssp. *ascendens* *Cynodon dactylon*	*Sorghum halepense*	—
1—25% occurrence	*Chenopodium album* *Cirsium arvense* *Convolvulus arvensis* *Datura stramonium* *Daucus carota* *Digitaria ischaemum* *Hibiscus triomum* *Lathyrus tuberosus* *Solanum nigrum*	*Amaranthus albus* *Bilderdykia convolvulus* *Cirsium arvense* *Equisetum arvense* *Lithospermum arvense* *Matricaria inodora* *Papaver rhoeas* *Poa trivialis* *Polygonum lapathifolium* *Solanum nigrum* *Setaria viridis*	*Amaranthus albus* *Amaranthus viridis* *Anagallis arvensis* *Chenopodium album* *Convolvulus arvensis* *Digitaria ischaemum* *Heliotropium europaeum* *Hibiscus triomum* *Polygonum lapathifolium* *Stachys annua* *Sorghum halepense*
Extent of infection by *Sorghum halepense*	High	Medium	Low

Table 3

Distribution of samples by phenophase

Phenological phase	Bács almás	Nagy-kovácsi	Zichy-újfalu	Alag
5.5 medium heading	2	—	8	1
5.9 full heading	6	17	21	13
6.1 milky grain	16	55	21	71
6.4 dough grain	38	24	31	15
6.8 fully ripe	34	4	19	—
6.9 dead ripe	4	—	—	—

johnsongrass ecotypes he examined the number of verticils ranged from 5 to 14, the lengths of the internodes between them were 1—4 cm, while the flower production varied between 87 and 352 sessile flowers.

Description of *Sorghum halepense* spikelets. *Sorghum halepense* has spikelets of the andropogonous type (Potztal, in: MELCHIOR 1964). The sessile flower is bisexual, while the

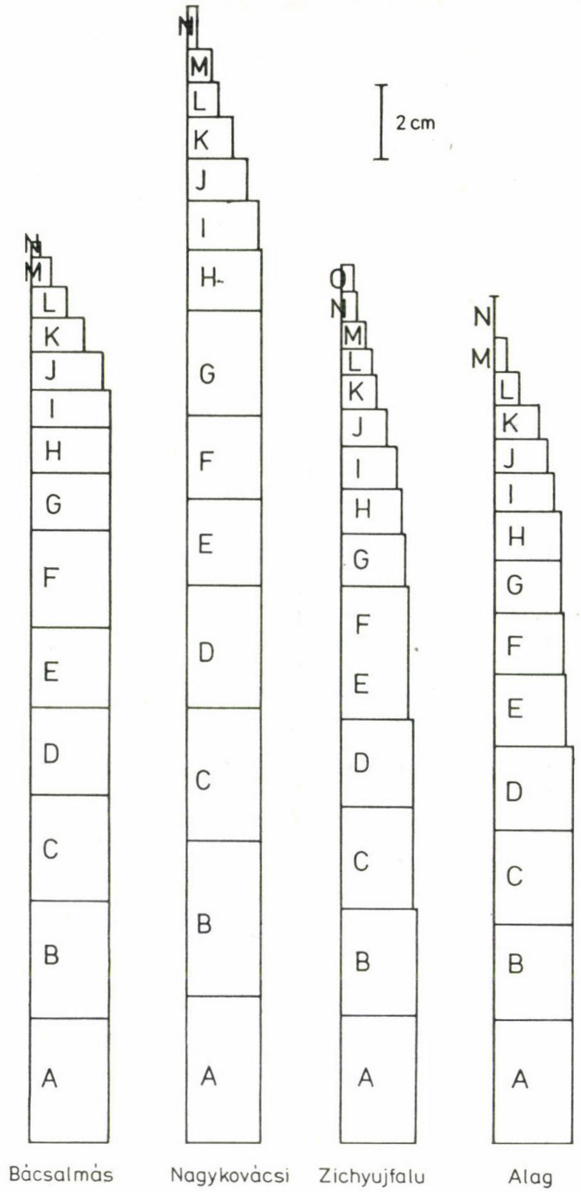

Fig. 3. Lengths of internodes in the four populations

pedunculate flower is male. The spikelet is generally composed of these two flowers, except for the terminal one, which contains a sessile fertile flower and two peduncular staminate or sterile flowers. According to HEGI (1936) the male flower is 5—6 cm long and has a 3—4 mm long peduncle. In HITCHCOCK (1951) the length of the sessile flower is 4.5—5.5 mm, the aristae is 1—1.5 cm and the peduncular flower 5—7 mm long, while Ghisa (in: SAVULESCU 1972) describes the bisexual flower as 5—6 mm long with a 3 mm long peduncle. Of the ecotypes studied by MCWHORTER (1971) 20% were without aristae. He described the length of the sessile spikelet as being 4.7—5.9 mm, and that of the peduncular spikelet as ranging from

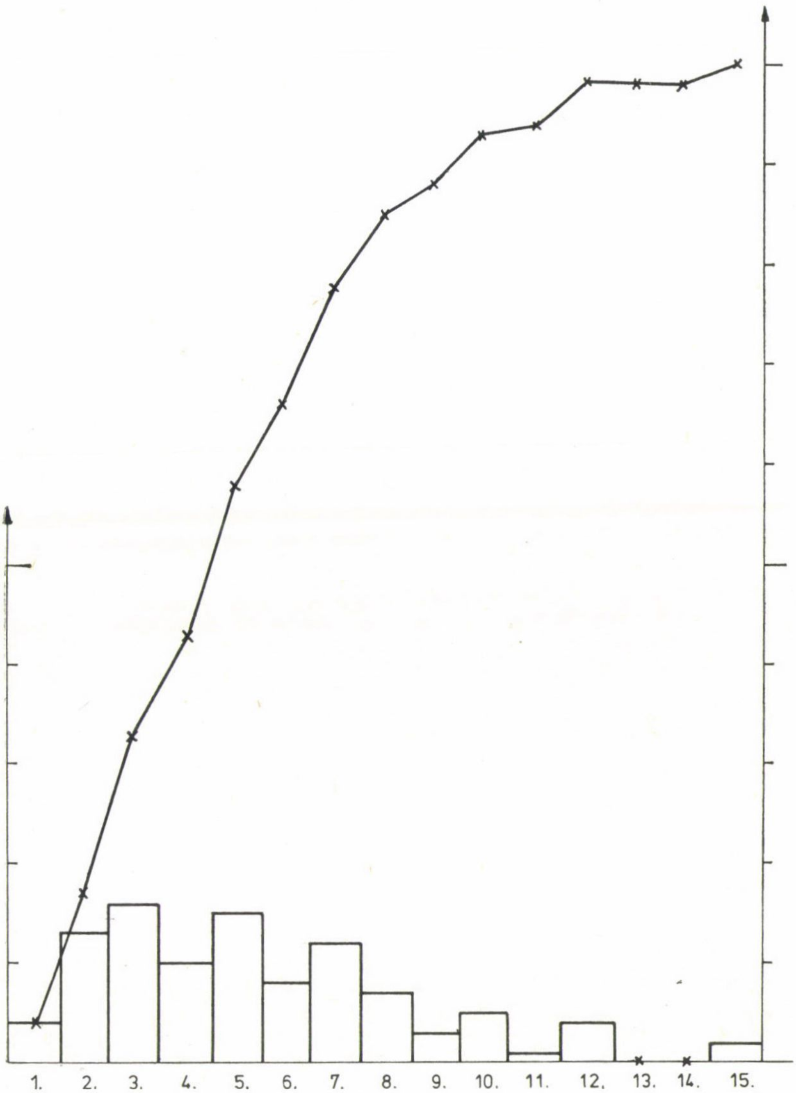

Fig. 4a

4.0 to 5.7 mm. Yamada—Adachi (in: King 1966) found the johnsongrass inflorescence to contain 700 flowers, 50% of which were bisexual and 50% male. The grain crop of *Sorghum halepense* is described by Scherman (1966). According to Ujvárosi (1973) the flumes are mostly awnless (it should be noted that the specimens encountered during the present study were mainly aristate).

Czakó (1973) used 14 characters for the biomathematical differentiation of Festuca wagneri and Festuca vaginata, of which 10 were characteristics of the panicle.

Csányi-Kovács—Horánszky (1973) used eight morphological features to characterize Festuca populations. Fischer *et al.* (1974) used 12 properties of the panicle for the differentia-

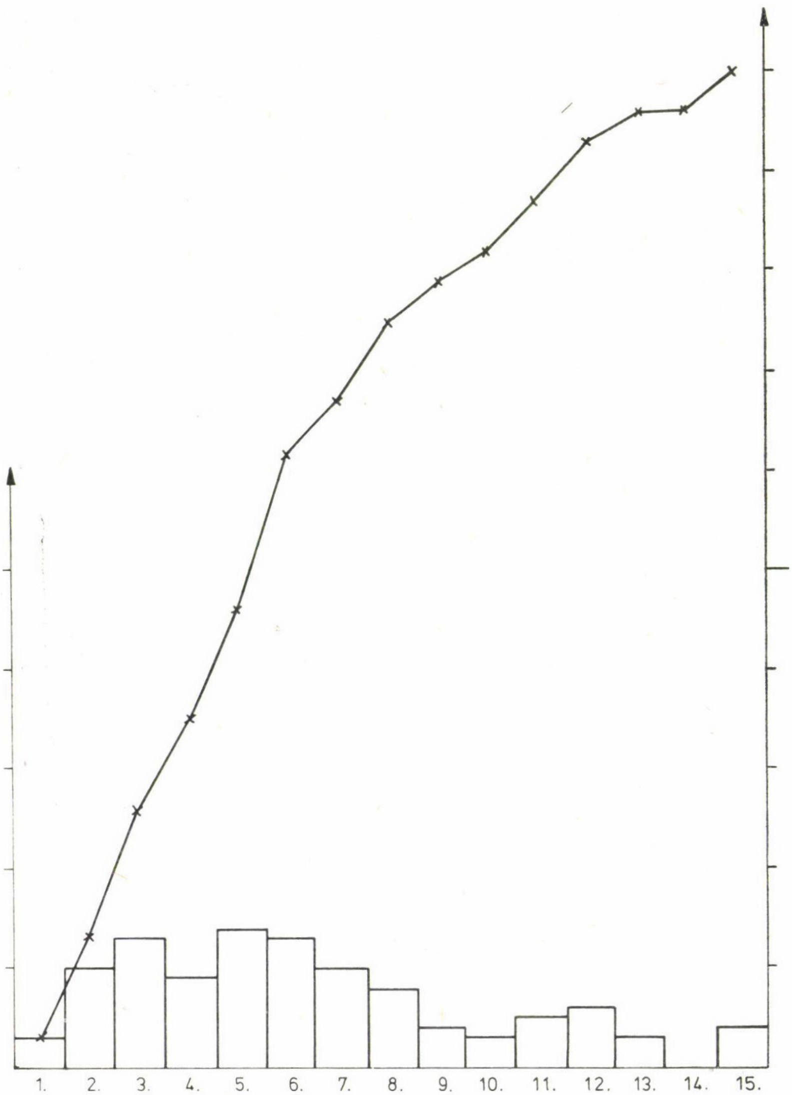

Fig. 4b

tion of Festuca pseudovina populations in a study based on discrimination analysis. In the present work a large number of properties were examined. Table 4 contains 24 characteristics. If the primary ramifications of the different verticils (Table 6), the secondary ramifications (Table 7) and the length of the internodes (Fig. 3) were considered as separate characteristics, the examined features would total more than 100. Nearly 20 characters were measured in 100 samples per population, while the other characters were studied in every third sample chosen from the above group of 100, i.e. in 34 samples each. The above data are summarized in Table 4.

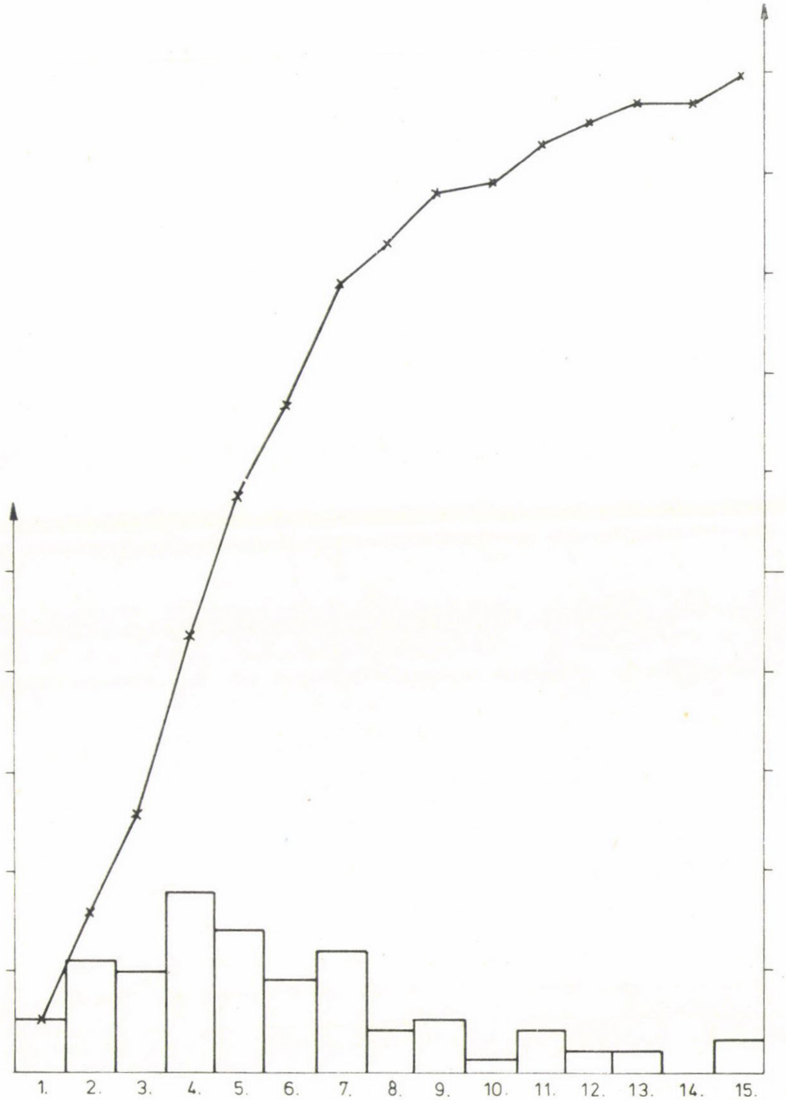

Fig. 4c

When taking the measurements it must not be overlooked that some of the panicles are injured or broken to a greater or lesser extent even when collected in the field; the samples measured do not consist only of perfect, whole parts. Hence, all the properties of all the samples cannot be measured with the same accuracy. (The spread of Sorghum halepense by means of the grain is greatly promoted by the fact that the branches of the panicle readily fall apart and the grains drop. Even the most careful examination cannot prevent this happening to some extent.)

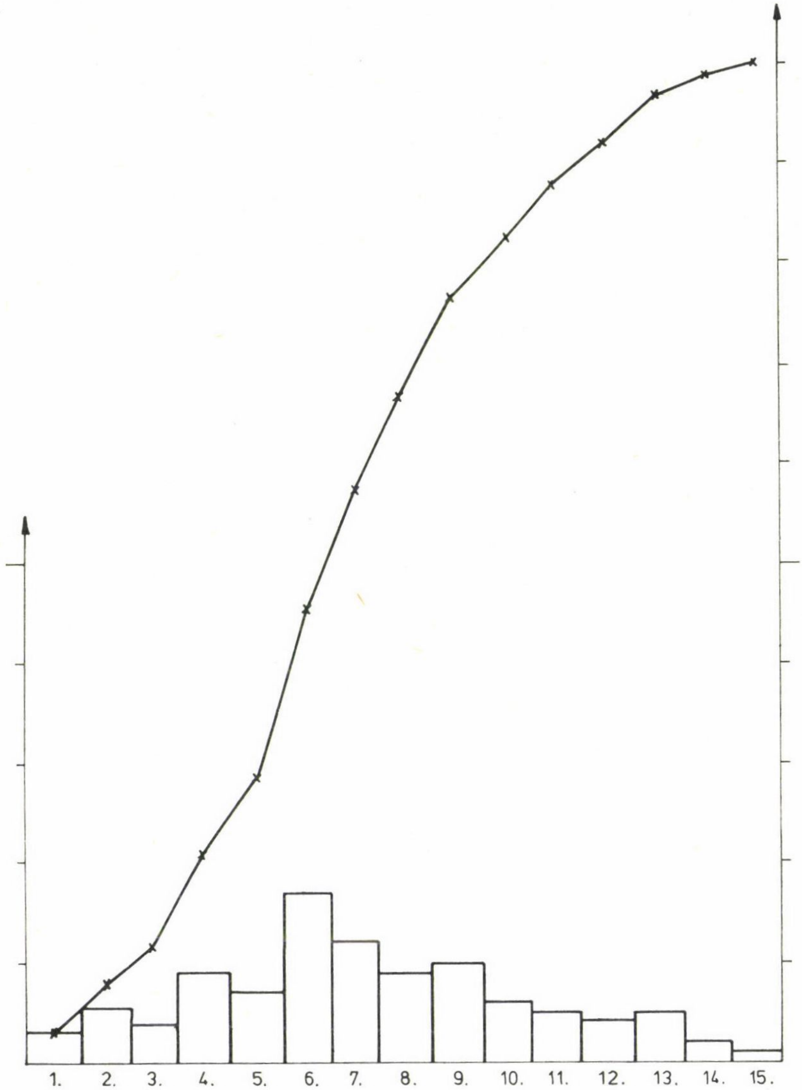

Fig. 4d

Fig. 4. Frequency distribution of panicle weights. The figures on the abscissa indicate the frequency gradations. The steadily rising line is the cumulative frequency [*a)* Bácsalmás, *b)* Nagykovácsi, *c)* Zichyújfalu, *d)* Alag]

Table 4

Characteristics used in the 1976 evaluation of johnsongrass

	Number of characteristics examined per panicle	Data per panicle in theory	Number of populations examined
Length of panicle	1	100	4
Weight of panicle	1	100	4
Number of primary ramifications per verticil, A—R verticils	18	100	4
Total number of verticils/panicle	1	100	4
Total primary ramifications/panicle	1	100	4
Number of spikelets/panicle	1	34	4
Number of flowers/panicle	1	34	4
Number of spikelets on the longest primary ramification of verticil II	1	34	4
Number of flowers on the longes primary ramification of verticil II	1	34	4
Length of the longest primary ramification on verticil I	1	100	4
Length of the longest primary ramification on verticil II	1	100	4
Length of internode, A—O internodes	15	34	4
Number of secondary ramifications per primary ramification	72	34	4
Total secondary ramifications/panicle	1	34	4
Number of three-flower spikelets/panicle	1	34	4
Length of sessile spikelets	1	6×34	4
Maximum width of sessile spikelets	1	6×34	4
Maximum thickness of sessile spikelets	1	6×34	4
Length of peduncle in peduncular spikelets	1	6×34	4
Length of peduncular spikelets	1	6×34	4
Maximum width of peduncular spikelets	1	6×34	4
Maximum thickness of peduncular spikelets	1	6×34	4
Length of aristae	1	6×34	4
Hundred-grain-weight	1	3	

In the course of the evaluation the arithmetic means and the standard deviations for all the characters and all the populations were determined from the data listed in Table 4 using a Hewlett-Packard 67 computer. Apart from other statistical characteristics, the frequency distributions were examined in the form of a histogram. The conclusions reached in the present paper are supported by more than 400 histograms and several thousand statistical data. The histograms generally reveal that the normal distribution was only approximated, though no U-distribution was shown. The frequency curve was mostly asymmetrical. This is in agreement with the results of a morphological examination on panicles carried out by Horánszky (1970) who found that the atypical Gauss curve was dominant (Figs 4, 5, 6). In order to achieve uniform character weighing, 19 representative characters were chosen from those listed in Table 4 and an effort was made to give a primary characterization of the panicles and thus to differentiate the populations. The 19 characters chosen are shown in Table 5, which contains the averages and the relevant standard deviations. In choosing the representative characters care was taken to ensure that the individual groups of characters were uniformly represented. The length of internodes, the number of ramifications per verticil, etc. will therefore be discussed later; of these, only the totalled values of ramifications and verticils were included in Table 5.

Table 5

Mean values and standard deviations of 19 parameters chosen for the primary characterization of the populations

	Bácsalmás		Nagykovácsi		Zichyújfalu		Alag	
	X	S	X	S	X	S	X	S
1. Length of panicle	22.2	3.5	26 7	4 6	19.8	4.8	19.8	3.4
2. Weight of panicle	90.3	46.8	127.4	55.6	65.6	35.4	28.8	11.4
3. Total verticils/panicle	12.9	2.0	12.5	2.1	11.6	3.7	11.8	2.6
4. Total primary ramifications/panicle	32.8	8.1	31.1	5.5	28.6	13.0	33.4	8.4
5. Number of spikelets/panicle	122.2	38.0	190.3	54.8	99.6	43.3	99.4	30.6
6. Number of flowers/panicle	264.8	95.5	499.0	173.0	212.6	103.1	202.1	65.6
7. Number of spikelets on the longest ramification of verticil II	11.4	5.2	17.7	6.0	12.4	8.5	7.5	2.6
8. Number of flowers on the longest ramification of verticil II	25.6	13.4	39.6	13.6	22.7	19.7	15.1	6.8
9. Width of panicle I	8.3	2.4	11.3	3.0	7.9	2.1	8.0	2.5
10. Width of panicle II	7.5	2.0	11.0	2.5	6.9	1.8	6.4	1.8
11. Length of sessile spikelet	5.0	0.4	4.9	0.3	4.9	0.4	4.8	0.3
12. Width of sessile spikelet	1.9	0.2	1.9	0.2	1.7	0.2	1.8	0.2
13. Thickness of sessile spikelet	1.4	0.2	1.3	0.2	1.2	0.2	1.1	0.2
14. Length of peduncular spikelet	5.2	0.6	5.3	0.5	5.0	0.6	4.7	0.3
15. Width of peduncular spikelet	1.1	0.2	1.2	0.2	1.3	0.3	1.2	0.2
16. Thickness of peduncular spikelet	0.8	0.2	0.9	0.1	0.9	0.3	0.7	0.2
17. Length of peduncle in peduncular spikelets	2.2	0.5	2.6	0.4	2.3	0.4	2.3	0.4
18. Length of aristae	8.1	2.1	8.5	1.7	8.3	2.0	6.9	2.1
19. Hundred-grain-weight	49.3	1.5	52.3	2.5	53.0	2.0	51.7	1.2

Abbreviations: X = arithmetic mean,
S = standard deviation.

The values in Table 5 are shown in Fig. 2 in the form of a polygon based on a proportional scale, thus giving an illustrative comparison of the populations. This polygonal graph method (DAVIS—HEYWOOD 1963) illustrates the arithmetical means and the standard deviations.

Each radius represents one character, indicated on the radius by a number corresponding to the listing in Table 5. (The highest mean value represents a 100% distance on the radius.) The question must naturally be raised of whether it is correct to characterize the populations by comparing the averages of the characters and the standard deviations one by one. In the relevant literature (CSÁNYI-KOVÁCS—HORÁNSZKY 1973) this is an accepted method, suitable for an approximate evaluation of the characters and for a rough differentiation of the populations, though the mean values must be used carefully as they do not shed any light on the variation between plants and organs (DAVIS—HEYWOOD 1963).

The question may arise whether the relatively simple method employed can be regarded as adequate compared to up-to-date computer techniques (discrimination analysis, cluster

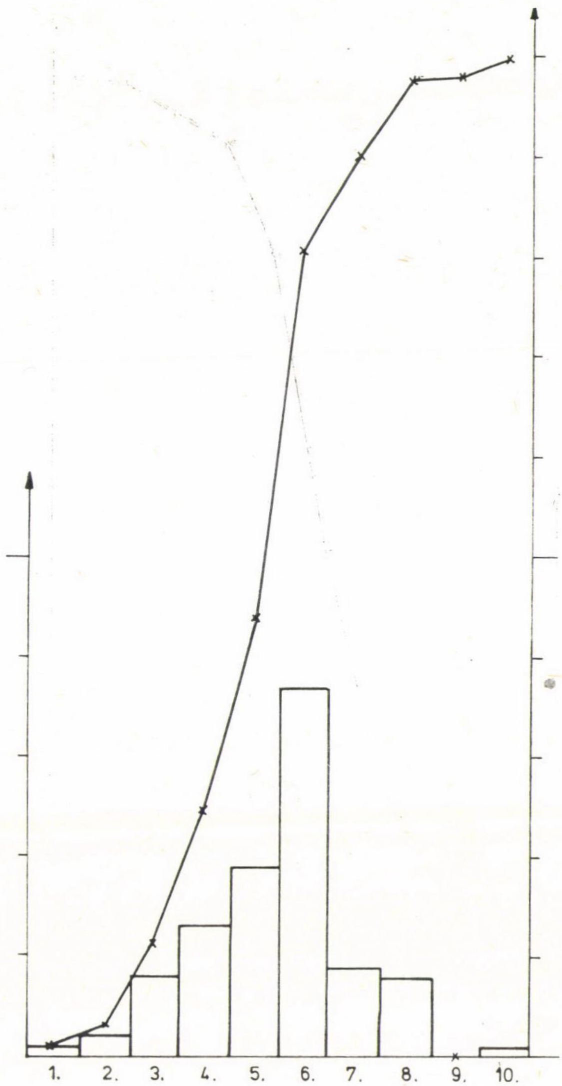

Fig. 5a

analysis, variance analysis). The use of the method is mainly justified by the fact that many valuable data series, which give a fuller picture of the johnsongrass groups examined, are not suitable for analysis with these computer methods. Two major problems should be pointed out here: owing to the intensive grain shedding characteristic of the *Sorghum halepense* populations examined, many data series are not complete, while a simultaneous computer analysis of nearly a hundred characters runs into difficulties. Of the almost 10,000 morphological data available, only a part were suitable for computer processing. The results of these examinations will be published later.

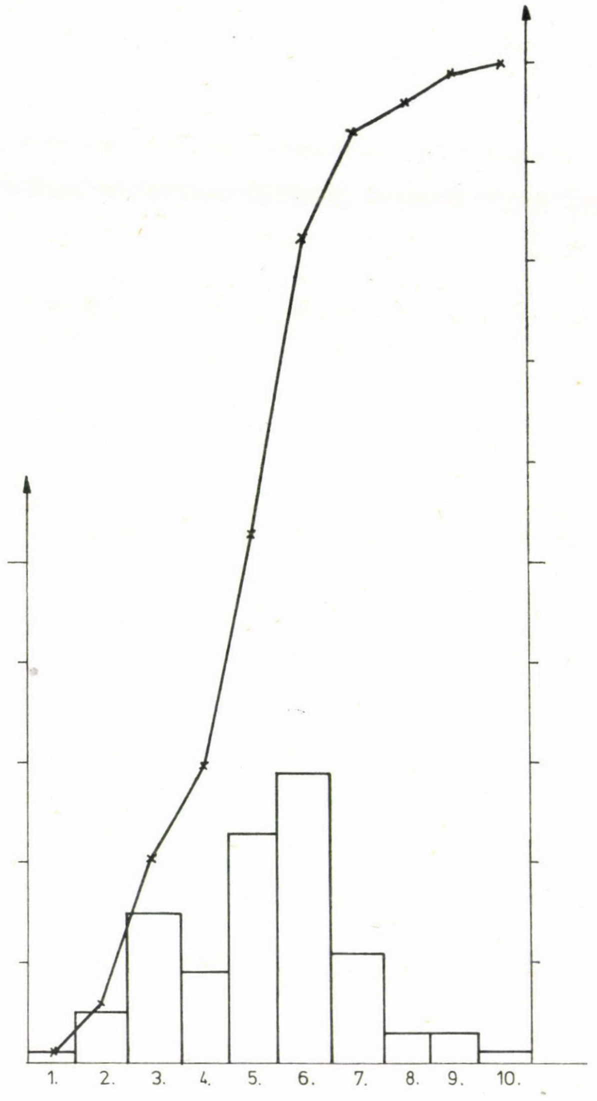

Fig. 5b

When considering the average values of the 19 characters in general, on the basis of the polygons in Fig. 2, the highest values are found in the Nagykovácsi clone and the lowest ones in the Alag clone.

For a visual comparison of the populations photos are presented in Fig. 1 showing panicles whose measurements are close to the average measurements of the four populations examined.

To explain the above, it must be taken into consideration that at the sampling date the Alag population was relatively the least mature (Table 3). The organic matter content in the soil at Alag was very low (Table 1), while in the Nagykovácsi plot it was very high.

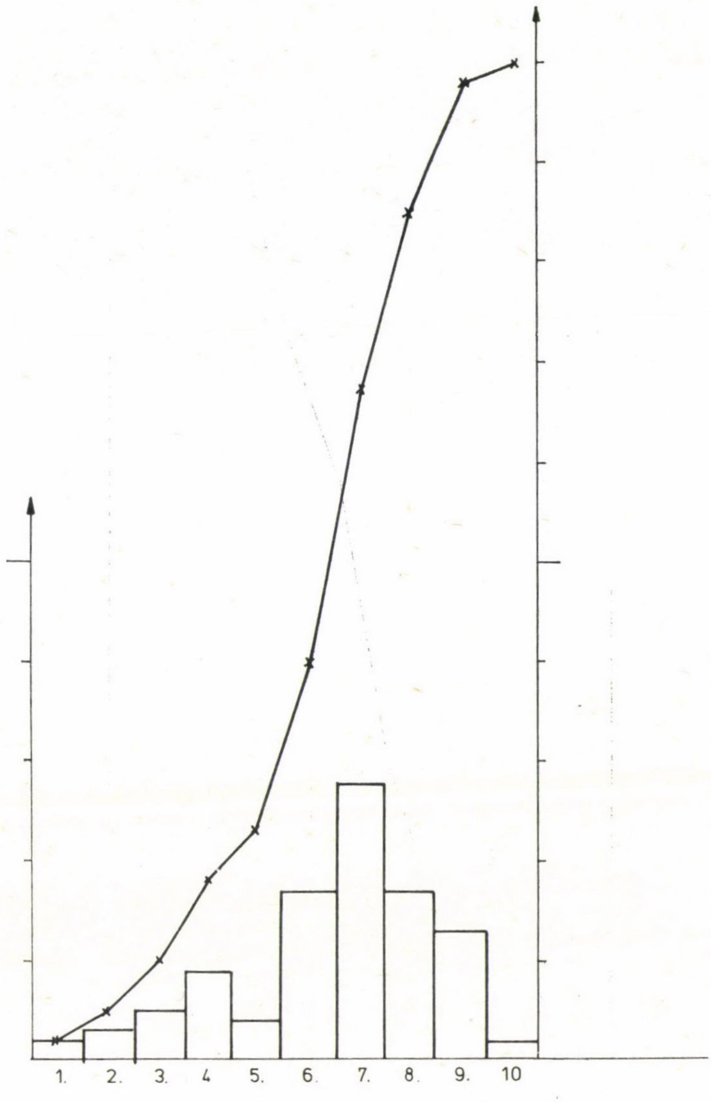

Fig. 5c

It must not be forgotten that on the Nagykovácsi trial grounds competition from cultivated plants and other weeds was eliminated. (This is one of the reasons why in 1977 the mature panicles were of considerable size both on sand and on the above-mentioned soil at the Nagykovácsi trial grounds. The size is thus not explained by the edaphic conditions alone.)

The frequency distribution of weeds at the Bácsalmás and Alag sites is very similar (Table 2), while the Agárd site showed a marked phytocoenological difference. On the other hand, the polygons for Bácsalmás and Agárd in Fig. 2 resemble each other much more, which suggests that the role of the phytocoenosis is less important.

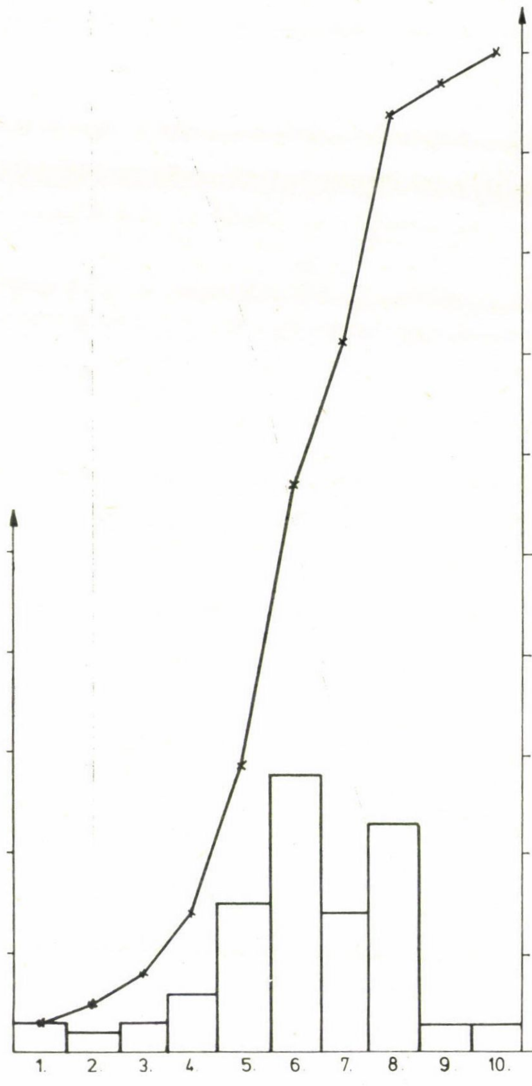

Fig. 5d

Fig. 5. Number of verticils (frequency distribution of the panicles) [*a)* Bácsalmás, *b)* Nagykovácsi, *c)* Zichyújfalu, *d)* Alag]

The standard deviation values are highest for the Zichyújfalu and Nagykovácsi populations. It can be seen that the difference between the populations for characters measured in cm, g and No. is sharper than for those measured in mm, though this may be due to the fact that the gradation of the scale for characters measured in mm is smaller. Comparing the polygons of the four populations the greatest difference is found for the following characters (the figures in brackets by the characters are the code numbers of the polygons on the basis of Table 5): panicle weight (Fig. 2, radius 2); spikelet number on the longest ramification of

Table 6

Number of primary ramifications per verticil in abaxial order

Verticils	Bácsalmás		Nagykovácsi		Zichyújfalu		Alag	
	X	S	X	S	X	S	X	S
A	2.0	1.2	2.7	1.2	2.8	1.5	2.4	1.3
B	2.6	1.0	2.6	1.0	2.5	1.1	2.4	1.0
C	2.4	1.0	2.4	0.9	2.4	1.1	2.6	1.1
D	2.7	1.1	2.6	0.8	2.6	1.1	2.9	1.1
E	2.6	1.1	2.5	0.9	2.5	1.1	2.9	1.0
F	2.6	1.1	2.7	0.9	2.5	1.2	2.9	1.0
G	2.7	1.1	2.5	0.9	2.6	1.2	2.9	1.1
H	2.7	1.2	2.6	0.9	2.4	1.3	3.1	0.9
I	2.7	1.1	2.5	1.0	2.5	1.3	2.9	1.1
J	2.6	1.2	2.3	0.9	2.4	1.1	3.1	1.0
K	2.5	1.0	2.5	0.8	2.4	1.1	3.1	1.0
L	2.3	1.0	2.3	0.8	2.1	1.0	3.1	0.9
M	2.2	1.0	2.0	0.7	2.3	1.0	2.8	1.0
N	2.5	0.9	1.9	0.7	1.9	0.7	2.8	1.0
O	2.5	0.8	1.9	0.5	2.3	0.9	2.5	1.0
P	2.5	0.5	1.9	0.9	2.1	0.6	2.8	0.8
Q	2.0	1.4	1.8	0.5	1.9	1.1	2.3	0.6
R	2.5	0.7	—	—	—	—	—	—

the 2nd verticil (Fig. 2, 7); number of flowers on the longest ramification of the 2nd verticil (Fig. 2, 8); spikelet number/panicle (Fig. 2, 5); flower number/panicle (Fig. 2, 6); width of panicle II (Fig. 2, 10).

For characters measured in mm the difference is most distinct for the thickness of sessile (Fig. 2, radius 13) and peduncular spikelets (Fig. 2, 16). It should be noted that in the populations from Nagykovácsi and Bácsalmás, which are of common origin, neither the means nor the standard deviation values are, for the most part, close to each other. Exceptions are the total number of verticils/panicle and the width of the sessile spikelet, where both the means and the standard deviation values are very close to each other; these properties are probably hereditary characters. (Frequency histograms for the number of verticils/panicle, the maximum width of sessile spikelets and the weight of the panicle are seen in Fig. 5, 6, 4.) Even in characters with different means the frequency distribution between two populations is often similar. It is graphically demonstrable that the differences between the four populations were found in characters of a definitely quantitative nature, which agrees with results obtained in *Festuca* (Fischer *et al.* 1974). As to the number of ramifications per verticil, Table 6 shows that these values in the Alag population are rather different from and generally much higher than those in the other three populations, which are relatively close to one another for these characters. In the populations with a common origin from Bácsalmás and Nagykovácsi the ramification data of the B-M verticils are strikingly similar, which again might suggest the

Fig. 6a

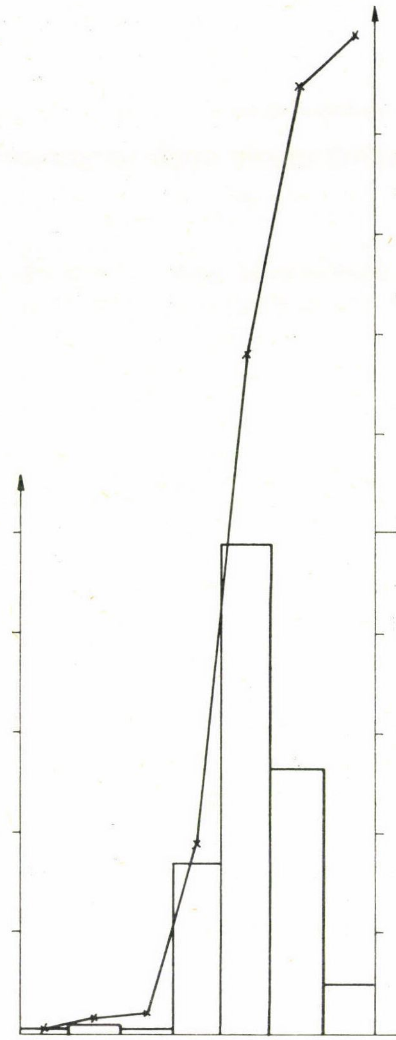

Fig. 6b

hereditary nature of the character. Fig. 3 compares the populations for the length of internode; the heights of the columns are proportionate to the lengths of the internodes, and their widths to the number of panicles which contained the internode in question. In Fig. 3 the four populations show very similar proportions. In the Zichyújfalu and Alag populations fewer panicles possessed further internodes after internodes E and C. Exceptions from the abaxially, gradually decreasing lengths of the internodes were the F internode in the Bácsalmás population and the G internode in the Nagykovácsi population, which were disproportionately long.

The total number of secondary ramifications/panicle is considerably higher in the two populations of common origin, which is all the more important because with respect to other

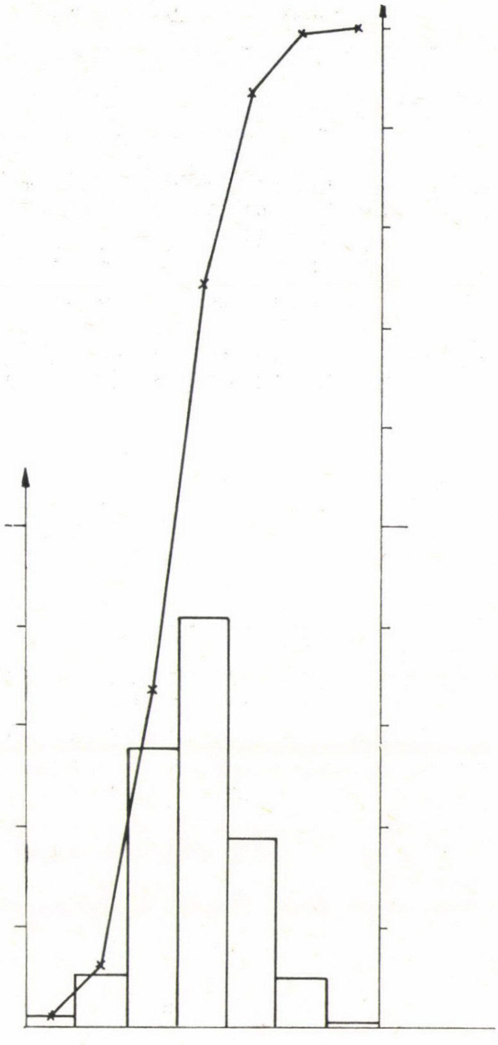

Fig. 6c

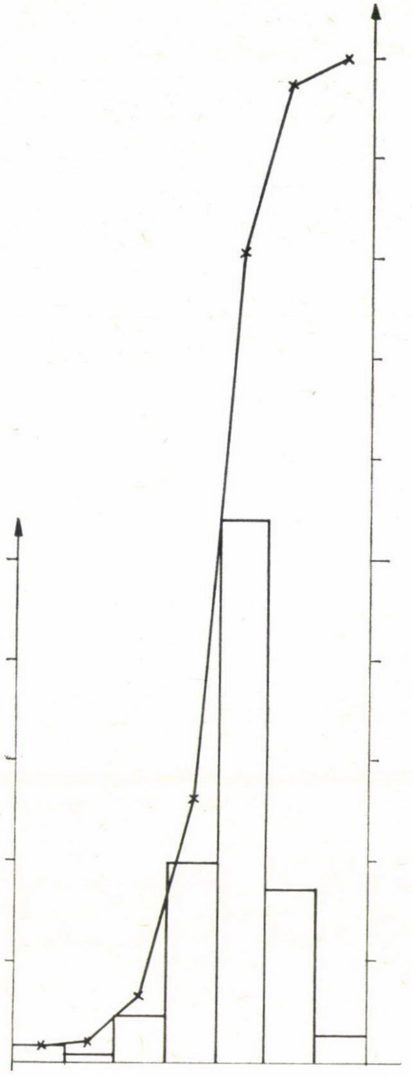

Fig. 6d

Fig. 6. Width of sessile spikelet, frequency distributions [*a)* Bácsalmás, *b)* Nagykovácsi, *c)* Zichyújfalu, *d)* Alag]

parameters (width of panicle, number of flowers, length of panicle and arista, etc.) the Nagykovácsi and Bácsalmás populations are often by no means close to one another (Table 7). The number of secondary ramifications per primary ramification is shown in Table 7. The primary ramifications on each verticil were placed in an order A-B-C-D according to the number of secondary ramifications (since placing the dried specimens in anatomical order would have been difficult and artificial). It is note-worthy that the number of secondary ramifications on all A, B, C and D primary ramifications of verticils I—IV is substantially

Table 7

Number of secondary ramifications

		Total secondary ramifications/panicle	I					II				III			
			A	B	C	D	E	A	B	C	D	A	B	C	D
Bácsalmás	X	63.6	6.8	5.9	4.5	5.0	—	5.7	4.6	4.4	4.8	4.8	4.9	4.6	3.0
	S	25.6	1.6	1.6	2.4	1.8	—	2.0	1.7	1.6	1.5	1.2	1.4	1.1	—
Nagykovácsi	X	83.0	7.4	6.6	6.4	6.1	—	6.7	6.1	5.5	5.8	5.8	5.2	4.6	4
	S	25.5	1.7	1.8	1.5	1.1	—	1.4	1.3	1.5	1.3	1.4	1.3	1.3	—
Zichyújfalu	X	38.1	6.2	5.3	4.9	5.3	—	5.2	4.0	3.8	5.0	4.6	4.0	4.3	3.8
	S	37.9	2.2	1.9	2.2	3.8	—	1.9	1.6	1.5	—	1.6	1.8	1.4	2.1
Alag	X	52.6	6.0	5.3	4.3	3.6	6	4.8	4.0	3.9	2.5	4.7	3.6	3.3	3.2
	S	23.8	2.4	2.1	1.9	1.8	—	2.1	1.7	1.2	0.7	1.6	1.6	1.7	2.2

		Total secondary ramifications/panicle	VII				VIII				IX			
			A	B	C	D	A	B	C	D	A	B	C	D
Bácsalmás	X	63.6	2.2	1.9	1.8	2.0	2.1	1.8	1.6	1.0	1.3	1.4	1.2	—
	S	25.6	1.2	0.9	0.9	—	1.0	0.8	0.5	—	0.5	0.6	0.5	—
Nagykovácsi	X	83.0	2.4	2.0	2.1	1.0	1.8	1.5	1.4	1.3	1.7	1.3	1.0	1
	S	25.5	0.9	0.9	0.7	—	0.8	0.6	0.7	0.5	1.0	0.5	—	—
Zichyújfalu	X	38.1	2.8	2.3	2.0	1.4	2.2	1.7	1.6	—	1.9	1.8	2.0	1
	S	37.9	1.2	1.1	0.6	0.6	1.4	0.9	0.9	—	1.2	0.8	1.0	—
Alag	X	52.6	1.9	1.6	1.3	1.0	1.6	1.1	1.0	1.0	1.7	1.3	1.0	—
	S	23.8	0.8	0.5	0.5	—	0.6	0.3	—	—	0.8	0.5	—	—

higher in the two populations of common origin than in the other two populations, which may indicate strict inheritance.

From the analysis of the four johnsongrass populations examined the following conclusions can be drawn:

Many characters (thickness of sessile and peduncular spikelets, number of primary ramifications on verticils B-M, number of secondary ramifications on the basal verticils, lengths of the F-G internodes) may be strictly hereditary; owing to the considerable differences between the populations it is worth paying special attention to these characters in the course of further investigations aimed at discovering the ecotypes.

In the Hungarian populations examined the panicles differ mainly in quantitative characters (number of flowers, number of spikelets, weight of panicle, width of panicle).

Comparing the frequency distribution conditions of weed species at the sites examined with the data on the panicles no evidence is found of a direct influence exercised by the qualitative composition of the weed coenosis on the panicle data obtained.

On the basis of frequency distributions it was reasonable to use the mean values for comparison.

per primary ramification

IV						V				VI			
A	B	C	D	E	F	A	B	C	D	A	B	C	D
3.9	3.6	2.9	3.0	—	—	3.2	3.0	3.4	2.5	2.5	2.2	1.7	2.0
1.3	1.0	0.9	0.6	—	—	1.2	1.1	1.2	1.3	1.2	1.1	0.8	—
4.8	4.1	3.9	3.5	—	—	3.9	3.6	3.2	3.7	3.3	2.9	2.7	2.3
1.2	1.3	1.2	0.7	—	—	1.1	1.1	1.0	0.6	1.3	1.2	1.2	1.3
3.5	3.2	3.5	3.2	—	—	3.4	3.0	2.8	3.2	2.9	2.5	2.5	2.6
2.0	1.8	1.9	2.3	—	—	1.7	1.4	1.3	1.8	1.4	1.3	1.5	1.7
3.3	3.0	2.6	2.3	—	—	3.1	2.4	2.1	1.7	2.3	1.8	1.7	2.0
1.6	1.4	1.5	1.4	—	—	1.4	0.9	0.6	0.8	1.3	0.8	0.7	—

X				XI				XII				XIII			
A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1.0	1.0	—	—	1.0	—	—	—	—				—			
0	0	—	—	0	—	—	—	—				—			
2.5	1.3	1.5	—	2.5	2.0	—	—	1	1	—	—	1			
0.6	0.6	0.7	—	0.7	1.4	—	—	—	—	—	—	—			
2.3	1.8	1.5	1	1.0	1.0	1	—	—				—			
1.0	1.0	0.6	—	0	0	0	—	—				—			
1.7	1.3	1.0	—	1.3	1.0	1	—	1				—			
0.8	0.5	—	—	0.6	—	—	—	—				—			

The polygonal graph method is suitable for comparing the data series of the johnson-grass populations examined; however, as a further check on the method the results obtained must in future be tested by evaluating a smaller part of the data with other statistical methods.

To reduce the considerable extent of variation within the populations it may be desirable to compare the different phenophases with each other.

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YIELD AND YIELD COMPONENTS OF EGYPTIAN CLOVER AS AFFECTED BY DIFFERENT FERTILIZERS

I. THE EFFECT OF THE CHEMICAL COMPOSITION OF EGYPTIAN CLOVER ON THE YIELD AND QUALITY OF COW'S AND BUFFALO'S MILK

Green fodder is the best feedstuff for dairy farm animals. The area on which forage can be grown is already limited and is going to shrink as a result of the building of new towns and factories.

Efforts must be concentrated on increasing the productivity per unit of cultivated area. Fertilization is an effective way of doing this. Stobbs (1975) stated that increasing the N, P, Ca and Mg in leaf and stem fractions increased the milk yield, and the solid not fat and protein contents of the milk. Higher intakes of feed supplying more digestible crude

Table 1

The nutritional components and feeding value of daily feeds

Animals	Feeds	Nutritional components, kg				Feeding value	
		crude protein	ether extract	crude fibre	N-free extract	starch equiva-lent	digest-ible protein
						kg	
Cows	1st cut berseem + corn stalks + C.M.*	1.99	1.11	3.87	5.74	5.22	0.89
	2nd cut berseem + corn stalks + C.M.*	1.77	1.00	3.60	5.58	5.92	0.87
	3rd cut berseem + corn stalks + C.M.*	1.85	1.05	3.81	5.73	6.05	0.92
	4th cut berseem + corn stalks + C.M.*	2.46	1.73	6.64	8.00	6.32	0.95
Buf-faloes	1st cut berseem + corn stalks + C.M.	2.34	1.30	4.75	6.98	6.28	1.06
	2nd cut berseem + corn stalks + C.M.	2.10	1.17	4.43	6.80	7.08	1.04
	3rd cut berseem + corn stalks + C.M.	2.19	1.22	4.68	6.98	7.23	1.10
	4th cut berseem + corn stalks + C.M.	2.88	2.00	7.91	9.58	7.53	1.13

C.M.* – Manifactured concentrate mixture composed of cotton seed cake 65%, extracted rice bran 20%, wheat bran, molasses 3%, calcium carbonate 2%, and sodium chloride 1%. This mixture contains 18.2% crude protein and 18.5% crude fibre.

The quantities of feed offered daily were: averages for four cows 35 kg berseem, 5.5 kg corn stalks and 2.88 kg concentrate mixture; averages for buffaloes 40 kg berseem, 7.25 kg corn stalks and 3.5 kg concentrate mixture.

These quantities were fixed throughout the experiment and were sufficient to cover the requirements (maintenance and productivity) as recorded by Ghoneim (1958).

protein per kg 4% FCM, resulted in higher milk, fat, protein and FCM yields (Mo 1972). Therefore the present work was designed in order to study the effect of different fertilizers (Folyfertile, Bifolan and nutrine) in comparison with super phosphate (15.5% P_2O_5) on the chemical composition of berseem in four cuttings. Studies on the changes in milk yield due to these different fertilizer treatments and their effect on milk components were important aims in this work.

Daily representative samples of berseem from each fertilization treatment in the four cuttings were taken for drying and moisture determination. The daily dried samples for each treatment and for each cutting period were gathered separately, ground and stored in firmly covered jars for chemical analysis. This work was begun in February 1976 and continued to the end of April 1976, and was repeated in the next season from December 1976 until March 1977. Four cross-bred cows (Jersey × Friesian) and four Egyptian buffaloes from the El-Minia University herd were included in this study 10 weeks after parturition. The average body weights were 408 ± 35.8 and 594 ± 26.3 kg for cows and buffaloes respectively. The animals were arranged in a latin square design in the two seasons, feeds were offered according to their maintenance and production requirements. Berseem was fed daily in the morning at 8 a.m. in a portion sufficient to cover 50% of their requirements, while the rest of the requirements were met using a manufactured concentrate mixture and pelleted corn stalks which were given at 4 p.m. (Table 1).

Table 2

Chemical composition of berseem on a dry matter basis in the two seasons

Cutting	Fertilizer	First season					
		Organic matter	Crude protein	Ether extract	Crude fibre	N-free extract	Ash
		%					
	1	84.50	18.49	7.08	16.24	42.69	15.50
	2	83.31	18.12	7.49	17.84	39.87	16.41
First	3	84.23	15.42	6.67	16.81	45.33	15.77
	4	83.60	18.46	8.20	16.52	40.42	16.40
	Average	83.91	17.62	7.36	16.85	42.08	16.10
		±0.28	±0.74	±0.33	±0.35	±1.25	±0.28
	1	84.80	21.53	5.47	17.99	39.81	15.20
	2	83.65	19.67	7.61	19.89	36.44	16.38
Second	3	85.13	20.34	8.26	18.97	37.56	14.87
	4	84.97	23.48	7.78	17.59	36.12	15.03
	Average	84.64	21.26	7.28	18.61	37.48	15.37
		±0.34	±0.84	±0.62	±0.52	±0.84	±0.34
	1	88.60	15.31	6.95	28.00	38.35	11.40
	2	88.22	18.58	3.77	23.97	41.89	11.78
Third	3	88.68	17.80	3.10	24.92	42.85	11.33
	4	88.83	18.96	4.89	25.10	39.88	11.17
	Average	88.58	17.66	4.68	25.50	40.74	11.42
		±0.13	±0.85	±0.85	±0.87	±1.01	±0.13
	1	89.10	18.54	3.06	27.73	39.76	10.90
	2	88.79	18.50	4.12	29.68	36.50	11.21
Fourth	3	88.63	17.39	2.67	27.70	40.88	11.37
	4	89.72	17.72	5.83	30.38	35.80	10.28
	Average	89.06	18.04	3.92	28.87	38.24	10.94
		±0.24	±0.29	±0.71	±0.68	±1.23	±0.24
	1	87.29	19.23	12.43	21.93	33.71	12.71
	2	86.08	17.63	11.39	22.78	34.26	13.92
First	3	86.68	17.17	11.55	22.85	35.11	13.32
	4	86.03	16.57	11.12	21.23	37.11	13.97
	Average	86.52	17.65	11.62	22.20	35.05	13.48
		±0.30	±0.57	±0.29	±0.39	±0.75	±0.30
	1	86.22	18.26	10.92	20.78	36.25	13.78
	2	86.52	17.57	11.09	20.06	37.85	13.43
Second	3	85.76	16.04	11.68	21.77	36.22	14.29
	4	86.35	14.85	11.99	20.99	38.51	13.65
	Average	86.21	16.68	11.42	20.90	37.21	13.79
		±0.17	±0.77	±0.25	±0.35	±0.58	±0.19
	1	87.51	16.53	11.31	23.29	36.39	12.49
	2	87.39	18.06	11.33	22.72	35.28	12.61
Third	3	86.79	16.35	11.34	23.08	36.03	13.21
	4	87.97	15.82	11.38	21.06	39.82	12.03
	Average	87.42	16.69	11.34	22.54	36.88	12.59
		±0.24	±0.48	±0.02	±0.51	±1.01	±0.24
	1	87.87	12.55	10.12	31.22	33.98	12.13
	2	87.56	11.85	10.43	30.93	34.36	12.44
Fourth	3	88.26	12.21	10.05	31.05	34.95	11.74
	4	87.35	13.06	10.81	30.58	32.90	12.65
	Average	87.76	12.41	10.35	30.95	34.05	12.24
		±0.20	±0.26	±0.18	±0.14	±0.43	±0.20

Each trial consisted of a 15 day preliminary period followed by a 10 day period of collecting representative milk samples for chemical analysis (crude protein, fat, total solids and ash). Lactose and solids not fat % were obtained by the difference in each sample of milk. Milk production was recorded daily. The animals were milked twice a day at 8 a.m. and 4 p.m.

The chemical analysis of berseem and milk was carried out according to A.O.A.C. (1959) recommendations. Milk fat was determined as suggested by GERBER (1892). Statistical analyses were carried out according to SNEDECOR (1957).

Table 2 shows the chemical analysis of berseem in different cuttings using the four fertilizer treatments in the two seasons. The values were calculated on a dry matter basis. No significant differences could be observed due to fertilizer treatments in the two seasons, while there were highly significant variations between the different cuttings. These results were confirmed in the two seasons. It is quite clear that with increasing plant age there were increases based on the organic matter and crude fibre percentages; the differences were significant ($P < 0.01$). On the other hand, the first two cuttings were higher than the others in crude protein content; the differences were again significant ($P < 0.01$). There was also a decrease in ether extract percentage as the plants progressed in maturity; the differences were statistically significant ($P < 0.05$). The ether extract percentages were higher in the second season than in the first. Significant differences were found between the cuttings for N-free extract percentages, but there were no obvious trends in this respect. Ash content was higher in the first cut than in the later ones; the differences were significant ($P < 0.05$).

The data recorded in Table 3 (a and b) indicates that there were highly significant differences between cows and buffaloes in whole milk yield (kg/week), total solids % and fat % in the two seasons, while the variations in crude protein % were highly significant ($P < 0.01$) in favour of buffalo's milk in the first season only. The values in the second season tended to be higher for buffalo's milk but the differences were not statistically significant. No significant differences between cow's and buffalo's milk could be detected in the solid not fat and lactose percentages. Ash was found in traces in the milk of the two breeds used in this work; it ranges between 0.61—0.77%.

In the first season there were no significant differences in milk composition between the different cuttings except in solid not fat %, which was significantly higher in the milk when berseem of the second cut was fed than when the animals were fed the third cut. On the other hand there were highly significant differences in milk composition when berseem of different cuttings was fed, especially in total solids %, solid not fat % and lactose %, while the differences were only significant with respect to whole milk yield (kg/week) and crude protein % in the second season. The milk of animals fed the first cut berseem was characterised by higher total solids %, solid not fat % and lactose % than when other cuttings were fed; the differences were significant ($P < 0.01$). When animals were fed berseem of the fourth out, the whole milk yield was lower than when the other cuttings were fed. With reference to the crude protein percentage, this reached a peak when the animals were fed berseem of the third cut. Significant differences were found in the crude protein % of milk between animals fed the first, second and third cuttings of berseem.

When milk yield (kg/week) is adjusted according to the fat percentage and considered as 4% fat corrected milk for cows and 7% fat corrected milk for buffaloes, the data illustrated in Table 3 (a and b) clearly show that the FCM yield was the lowest in each season when the last cut of berseem was fed. The differences were significant only in the second season in the case of buffaloes. There were no statistically significant effects of different fertilizer treatments on milk yield or its composition.

The data in Table 2 indicate that the different fertilizer treatments have no significant effect on the chemical composition of berseem, but it may have an effect on the crop yield.

Table 3a

Milk yield of cows and buffaloes and

Cuttings	Fertilizer	Milk yield, kg/week		Fat corrected milk, kg/week		Total solids, %	
		Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes
First	1	65.3	42.5	56.1	50.0	16.6	19.8
	2	70.0	64.5	69.5	53.1	13.3	19.8
	3	67.2	56.0	70.8	40.7	15.2	15.0
	4	66.5	57.5	61.7	47.7	14.9	15.8
	Average	67.3	55.0	64.5 ± 3.5	47.8 ± 2.6	14.0	17.6
Second	1	53.5	45.0	60.7	45.9	20.1	17.9
	2	59.0	29.4	66.0	40.0	16.0	20.9
	3	66.0	63.7	72.6	58.5	14.2	17.3
	4	62.0	44.5	71.5	45.0	16.4	21.4
	Average	60.1	45.7	67.7 ± 2.8	47.3 ± 3.9	16.7	19.4
Third	1	61.0	35.5	53.9	35.9	12.0	17.4
	2	58.0	48.0	66.0	45.8	14.8	17.4
	3	58.0	23.2	56.4	23.8	13.0	18.9
	4	63.5	60.2	57.0	52.6	11.8	16.5
	Average	60.1	41.7	58.3 ± 2.7	39.5 ± 6.3	12.9	17.6

This results could be accepted if the concentrations of the different fertilizers did not reach the effective level or if these macro- or microelements were found in sufficient amounts in the soil so that any other increase would not appear in the chemical composition of the plants or reflect in their genetic performance.

Milk yield and its composition were not altered as a result of the different fertilizer treatments. This may be due to the similarity in chemical composition of berseem treated with different fertilizers. Martz and Ricketts indicated that in Guernsey cows fed on concentrates at a rate of 1 lb/2.5 lb milk yield plus hay fertilized with 100 and 200 lb/acre of P and K respectively or fertilized with this fertilizer plus 100 lb N/acre, there was no difference in milk yield due to the treatment, but N fertilization resulted in an increased yield of hay/acre. The crude protein in the hay was increased. Leonhard-Kluz *et al.* (1973) and Gorden (1973) concluded that there were no significant differences in milk yield and milk components (total solids, fat, protein and ash %) due to different levels of N fertilization in the range of 400 and 700 kg N/ha. On the other hand significant differences in milk yield and composition and berseem composition were expected between the different cuttings. There is good evidence that an advance in maturity is accompanied by a progressive increase in cell wall and lignine content and a decrease in digestibility (Olubajo *et al.* 1974, Abou-Raya 1951). It is also proved that early cuts of hay were higher in crude protein and lower in crude fibre percentages than late cuts of hay on a dry matter basis. These data are in agreement with the results of Galal (1970, 1974), Stobbs (1975), Gupta (1972) and Dijkstra (1971). In response to the different chemical compositions of berseem in the different cuttings, especially as regards *i t s chemical components in the first season*

Crude protein, %		Fat, %		Solid not fat		Lactose, %		Ash, %	
Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes
3.1	4.2	3.1	8.7	9.5	11.1	6.4	6.1	0.7	0.8
3.2	3.7	4.0	5.3	9.3	14.5	6.1	10.0	0.7	0.8
2.9	2.4	4.4	4.4	10.9	10.6	8.0	7.5	0.8	0.8
3.3	3.8	3.5	5.4	11.4	10.5	8.0	6.0	0.7	0.7
3.1	3.5	3.7	5.9	10.3	11.7	7.1	7.4	0.7	0.8
3.2	3.6	4.9	7.2	15.2	10.7	12.1	6.4	0.6	0.8
3.4	4.6	4.8	10.4	11.2	10.5	7.9	5.3	0.6	0.7
2.7	3.5	4.7	6.0	9.5	11.1	6.8	7.0	0.6	0.6
2.8	4.3	5.0	7.1	11.4	14.3	8.6	9.3	0.6	0.7
3.0	4.0	4.9	7.1	11.9	11.7	8.8	7.0	0.6	0.7
2.9	3.2	3.2	7.0	8.8	10.3	5.9	6.4	0.6	0.7
2.9	3.9	4.9	6.6	9.8	10.8	7.0	6.1	0.7	0.8
4.1	4.4	3.8	7.3	9.2	11.7	5.0	6.6	0.7	0.7
2.8	3.4	3.3	5.8	8.5	10.7	5.6	6.6	0.6	0.7
3.2	3.8	3.8	6.7	9.1	10.9	5.9	6.4	0.6	0.7

crude fibre %, there were significant differences in milk yield and composition. DONKER—MARTEN (1972) reported that 92% of the variations in milk yield could be explained by variations in the crude fibre content of the diet ($r = -0.96$). They also found that early cuts of hay contained 35% crude fibre. It is clear from Tables 2 and 3 that the fourth cut was distinguished by a lower percentage of crude protein, ether extract and N-free extract and a higher percentage of crude fibre on a dry matter basis.

The nutritive ratio for the first, second, third and fourth cuttings of berseem were 1 : 5.66, 7.69, 8.11 and 8.18 respectively (GALAL 1974). The higher percentage of crude fibre, the lower crude protein to crude fibre ratio (0.37 for the fourth cut compared with 0.51, 0.49 and 0.49 for the first, second and third cuts respectively) and the greater nutritive ratio of the fourth cut may explain the observed depression in milk yield during this period. As the protein quantity is an important factor affecting milk production, the protein quality, considered as the presence of different amino acids in appropriate quantities and proportions, all of which factors vary with the stage of plant maturity, may affect the milk yield (SMITH 1959). DONKER—MARTEN (1972) reported that the leafy young growth of pastures is higher in digestibility, protein, minerals and vitamins than hay which is cut in later stages of maturity when the crop is stemmy.

The significantly higher percentage of total solids in the milk when the first cut of berseem was fed (second season, Table 3b) compared with the other cuttings may be referred to the slightly lower milk yield when the animals were fed the first cut of berseem. BARNARD *et al.* (1970) stated that the yield and the total solids % are inversely related.

Table 3b

Milk yield of cows and buffaloes and its chemical

Cuttings	Fertilizer	Milk yield, kg/week		Fat corrected milk, kg/week		Total solids, %	
		Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes
First	1	61.0	42.5	56.2	44.7	15.4	18.1
	2	59.5	38.0	65.8	31.6	21.1	19.8
	3	44.0	37.0	40.1	40.0	20.3	17.7
	4	49.0	45.0	54.3	43.4	14.7	17.8
	Average	53.4	40.6	54.1 ± 5.3	39.9 ± 2.9	17.9	18.4
Second	1	53.0	43.5	50.1	46.6	12.7	17.7
	2	49.5	40.5	45.8	43.1	12.2	17.6
	3	69.0	56.0	73.5	47.0	12.9	14.7
	4	69.0	56.0	73.5	47.0	12.9	14.7
	Average	59.1	50.8	61.6 ± 8.0	46.6 ± 1.3	12.9	16.1
Third	1	74.5	47.0	84.6	47.9	13.0	16.0
	2	43.0	35.5	42.5	42.2	12.0	18.2
	3	63.0	34.0	62.6	39.4	11.9	18.7
	4	53.0	58.0	65.1	51.1	13.8	14.9
	Average	58.4	43.6	63.7 ± 8.6	45.2 ± 2.7	12.7	17.0
Fourth	1	28.5	43.5	37.1	37.7	14.2	15.4
	2	46.5	33.5	50.0	34.5	12.9	16.3
	3	33.0	26.0	38.4	31.3	13.5	17.9
	4	53.5	18.5	53.8	22.3	13.0	17.7
	Average	40.4	30.4	44.8 ± 4.2	31.4 ± 3.3	13.4	16.8

The variations in the chemical analysis of cow's and buffalo's milk in this study (Tables 4 and 5) reflect the specific differences and are in agreement with the literature for cows from temperate zones and for Egyptian buffaloes. FAHIMUDDIN (1975) recorded 3.7 and 5.5% for the fat percentage in cow's and buffalo's milk respectively, while Ghoneim and Taha el Katib gave the average milk fat % as 7.11% and HOFI *et al.* (1966) as 5.82%. In the present work the averages were 4.31 and 6.99% for cow's and buffalo's milk respectively. It is of interest to observe that the higher percentage of ether extract in berseem in the second season compared to the first reflects its effect on the average milk fat %, which was higher in the second season than in the first. These averages were 4.13 and 6.78% in the first season compared with 4.44 and 7.14% in the second season for cow's and buffalo's milk respectively.

More work is needed concerning the analysis of micro- and macroelements in berseem and milk which may be affected by different fertilizer treatments and had a marked effect on the feeding value of the milk. SMITH (1959) concluded that the composition of the milk can be readily changed in experiments of short duration, but these changes are only slight *components in the second season in four cuttings*

Crude protein, %		Fat, %		Solid not fat		Lactose, %		Ash, %	
Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes
3.4	3.1	3.5	7.5	11.9	10.6	7.8	6.8	0.7	0.7
3.2	3.8	4.7	5.4	16.4	14.4	12 5	9.9	0.7	0.7
3.0	2.2	3.4	7.8	16.9	10.0	13.3	7.1	0.7	0.7
2.3	4.0	4.7	6.7	10.0	11.2	6.9	6.4	0.7	0.8
2.9	3.3	4.1	6.8	13.8	11.5	10.1	7.6	0.7	0.7
2.4	4.4	3.6	7.7	9.0	10.0	5.9	4.9	0.7	0.8
3.7	2.7	3.5	7.6	8.7	10.0	4.4	6.6	0.7	0.7
1.8	2.6	5.3	5.0	8.7	9.6	5.3	6.6	0.7	0.7
1.8	2.6	4.4	5.5	8.5	9.2	6.0	5.9	0.7	0.7
2.7	3.0	4.2	6.7	8.7	9.7	5.4	6.0	0.7	0.7
3.0	4.1	4.9	7.2	8.1	8.8	4.4	4.0	0.7	0.7
3.6	4.5	3.9	8.8	8.1	9.4	3.8	4.1	0.7	0.8
3.7	4.5	4.0	8.5	8.0	10.2	3.5	5.0	0.7	0.8
4.0	4.0	5.5	5.9	8.3	9.0	3.6	4.4	0.7	0.7
3.6	4.3	4.6	7.6	8.1	9.4	3.8	4.4	0.7	0.7
3.6	3.7	6.0	5.7	8.2	9.7	3.9	5.3	0.8	0.7
3.0	3.6	4.5	7.3	8.4	9.0	4.7	4.8	0.7	0.7
2.7	3.1	5.1	8.9	8.4	9.0	5.0	5.1	0.7	0.8
3.9	3.8	4.1	8.9	8.9	8.8	4.3	4.2	0.7	0.8
3.3	3.5	4.9	7.7	8.5	9.1	4.5	4.8	0.7	0.7

over a long period of time. The animal body has a marvellous ability to adapt to drastic feed changes in a relatively short period of time. In this instance the animal body acts as a buffer and can balance deficiencies to some extent from the body's stores.

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*

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Table 4

F-values of chemical analysis of berseem in different cuttings in two seasons

Item	First season					
	Organic matter	Crude protein	Ether extract	Crude fibre	N-free extract	Ash
	%					
F-value between cuttings	159.91**	6.70*	7.22**	63.63**	6.27*	166.59**
Comparison between different cuttings using L.S.R.	C_4-C_1** C_4-C_2** C_3-C_1** C_3-C_2** C_2-C_1*	C_2-C_1** C_2-C_3** C_2-C_4**	C_1-C_4** C_1-C_3* C_2-C_4** C_2-C_3*	C_4-C_1** C_4-C_2** C_4-C_3** C_3-C_1** C_3-C_2**	C_1-C_2** C_1-C_4* C_3-C_2*	C_1-C_4** C_1-C_3** C_1-C_2* C_2-C_4** C_2-C_3**
F-value between cuttings	8.52**	24.06**	6.13*	220.91**	5.20*	8.33**
Comparison between different cuttings using L.S.R.	C_4-C_2** C_4-C_1** C_3-C_2** C_3-C_1*	C_1-C_4** C_3-C_4** C_2-C_4**	C_1-C_4** C_2-C_4* C_3-C_4*	C_4-C_2** C_4-C_1** C_4-C_3** C_3-C_2* C_1-C_2*	C_2-C_4* C_3-C_4*	C_2-C_4** C_1-C_4** C_2-C_3* C_1-C_3*

C = cutting.

Table 5

F-values of milk yield and its chemical components in two seasons

	Milk yield, kg/week	Fat corrected milk, kg/week (d)		Total solids	Crude protein	Fat	Solid not fat	Lactose
				%				
First season	Breeds (a) 20.11**	cows	buffaloes	17.24**	19.15**	25.01**	4.14	0.3
	Cuttings (b) 3.54	8.45	1.76	3.84	0.62	2.66	4.45* C_2-C_3*	2.38
Second season	Breeds 10.70**	1.33	5.91*	22.04**	3.18	27.06**	0.12	0.4
	Cuttings 5.81* C_2-C_4** C_3-C_4* C_1-C_4*		C_2-C_4* C_3-C_4*	7.35** C_1-C_2** C_1-C_3** C_1-C_4**	4.4* C_3-C_2** C_3-C_1*	0.86	18.03** C_1-C_3** C_1-C_4** C_1-C_2**	29.98** C_1-C_3** C_1-C_4** C_1-C_2** C_2-C_3*

(a) F-values between the two breeds.
(b) F-values between the different cuttings.
(d) Fat corrected for each breed was statistically analysed alone because the values for cows were corrected for 4% fat corrected milk, while for buffaloes the values were corrected as 7% fat corrected milk.

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COMPARATIVE ET STUDIES ON BERSEEM CLOVER GROWN AT DIFFERENT WATER TABLE DEPTHS

I. UNDER RAINFALL CONDITIONS

In some newly reclaimed areas, under certain conditions, there are problems in supplying all the water requirements of the plant, and the vegetation in these areas depends, apart from the rainfall, mostly on the ground water level. The present study was carried out to determine the evapotranspiration (ET) of Berseem clover (*Trifolium alexandrinum* L.) under conditions of natural rainfall and different water table levels. In addition, our aim was to re-evaluate some evaporation and evapotranspiration formulae with measured data under these conditions.

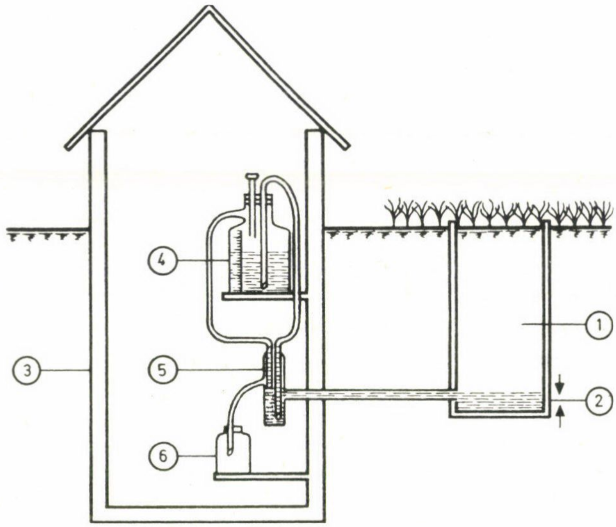

Fig. 1. Cross section of evapotranspirometer

These data are from an experiment conducted at the experimental station of the Water Management and Melioration Department of Gödöllő Agricultural University, to study the effect of water table levels and soil water regime on the evapotranspiration of Berseem clover var. El mescawi. The experiment was carried out during the 1976 and 1977 growing seasons.

18 lysimeters, 40 cm in diameter and 60 to 160 cm deep, were installed in the same manner as the THORNTHWAITE—MATHER (1955) type of evapotranspirometer (ANTAL 1966). The lysimeters were installed in two rows (2×9) at both sides of the measuring cellar as two replicates. An artificial water table was maintained above the bottom of all the lysimeters at a height of 10 cm by simple regulating instruments installed in the measuring cellar as shown in Fig. 1. In each of the two evapotranspirometer rows, three water table depths were established: at 50 cm (I), at 100 cm (II) and at 150 cm (III).

Each of the water table depths was established in three lysimeters, one of which was left uncovered throughout the season (I — 1, II — 1 and III — 1) to receive rainfall only, in addition to the ground water (which is what will be considered in this paper). The other two lysimeters were sheltered with plastic roofs so that they were covered at night and at the start of each rainfall and uncovered as soon as the rain came to an end. One of them was unirrigated, so the vegetation depended only on the ground water capillary fringe throughout the season (I — 2, II — 2 and III — 2) and the other was irrigated so as to be at field capacity (I — 3, II — 3 and III — 3).

The lysimeters were filled with a 15 cm layer of gravel, and then by sandy loam soil which represents the soil type of the surrounding area. The lysimeter site was surrounded by 40 m² area planted with the same crop and at least one kilometre of cultivated land in all directions.

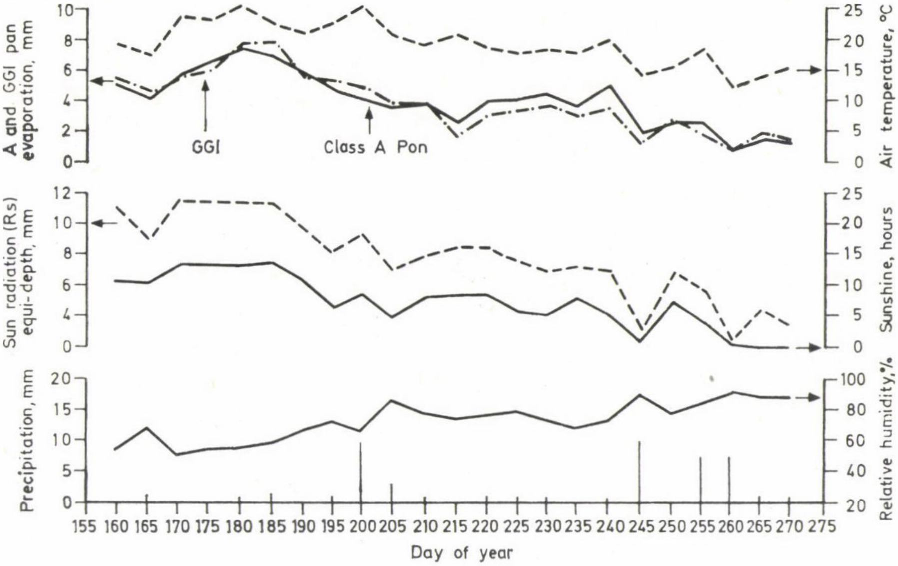

Fig. 2. Daily means of climatic factors in 1976 (5 days average)

Berseem clover (*Trifolium alexandrinum* L.) was planted on May 6, 1976 in one replicate and May 5, 1977 in two replicates. Three cuttings were taken on June 23, July 17 and October 1, 1976, and on June 24, July 19 and October 2, 1977, respectively.

Since the Berseem root system during the seedling stage is relatively shallow, frequent light irrigation was applied to maintain the soil moisture of all the lysimeters at field capacity until one week before the ET measurements.

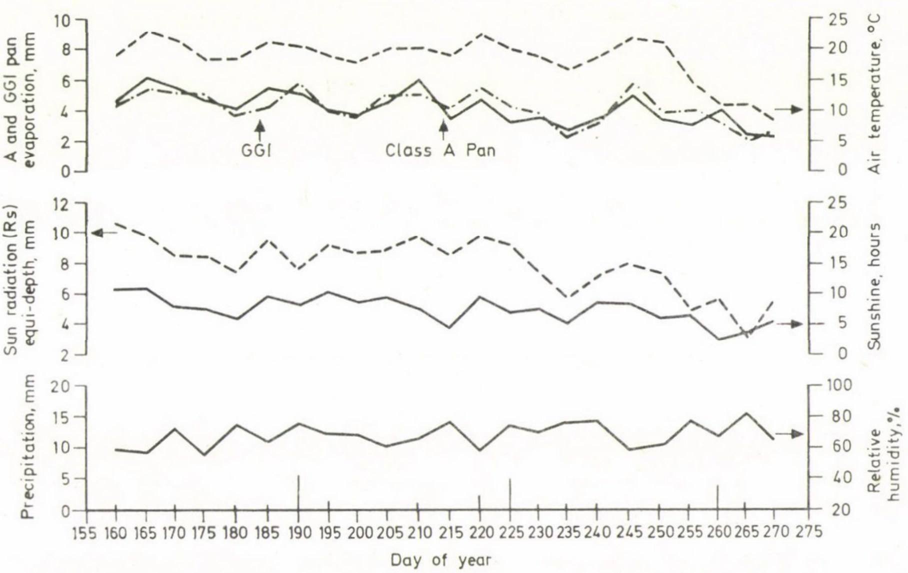

Fig. 3. Daily means of climatic factors in 1977 (5 days average)

Daily ET measurements were begun on June 8, 1976 and June 4, 1977 and ended on September 26, 1976 and September 27, 1977, respectively. At the same time, daily measurements of climatic components (air temperature, precipitation, humidity, wind velocity, sunshine, class A pan and GGI pan evaporation) were made at the experimental site. The total radiation data were taken from the National Meteorological Service Station in Budapest, about 30 km from the Gödöllő experimental site. The radiation data were expressed as equivalent depths of water evaporation. All the above measured data were generated and smoothed by a 5-day running average to show trends more clearly, as shown in Figs 2 and 3.

Table 1

Important features of ET estimating formulae

Basis of formulae	Name, year and country	Mathematical forms	Remarks
Energy balance	1. Jensen—Haise, 1963, USA	$ET_p = (0.014t - 0.37)\, R_s$	—
	2. Modified Jensen—Haise (Jensen *et al.* 1970), USA	$ET_p = (C_T t - C_T T_x)\, R_s$	C_T and T_x are coefficients depending on the air temperature and are constant in a given area
	3. Hargreaves, 1977a,	$ET_p = 0.0075t \cdot R_s$	—
Saturation deficit	4. Antal 1968, Hungary	$ET_p = 0.9\, (e_2 - e_1)^{0.8} \cdot (1 + \alpha t)$	$ET_{opt.} = ET_p \cdot k$
Sunshine duration and crop coefficient	5. Petrasovits 1970, Hungary	$ET_{opt.} = k \cdot t \cdot r$	k is a crop biotechnical factor depending on LAI
Multiple correlation	6. Christiansen 1968, USA	$E_v = 0.473\, R \cdot C_{T,W,H,S,E,M}$	$ET_a = E_v \cdot k$; k is a crop factor from tables (Hargreaves 1968)

The symbols used in this table are:

ET_p = potential evapotranspiration, mm/day;
$ET_{opt.}$ = optimum evapotranspiration, mm/day
ET_a = actual evapotranspiration, mm/day;
E_v = pan evaporation, mm/day;
R_s = global daily radiation, equivalent mm water evaporated;
R = mean extraterrestrial radiation, equivalent mm water;
r = daily percentage of the yearly sunshine;
t = daily mean temperature, °F (Jensen—Haise, Hargreaves), °C (Petrasovits, Antal);
e_2 = saturation vapour pressure, mm Hg
e_1 = actual vapour pressure, mm Hg;
$\alpha = \frac{1}{273}$;
k = crop coefficient;

$$C_T = \frac{1}{68 - 3.6 \cdot E\,(1000 + 487.6)\,(e_2 - e_1)};$$

$$T_x = 27.5 - \frac{(e_2 - e_1)}{3} - \frac{E}{1000};$$

E = ground surface elevation, in feet;
$C_{T,W,H,S,E,M}$ = coefficients for air temperature, air humidity, sunshine percentage, elevation and month, respectively.

Table 2

Seasonal totals and daily rate of measured evaporation, precipitation and ET for different water table levels

Year	Period of measurement		Class A pan	GGI pan	Precipitation	Measured ET shallow I-1	medium II-1	deep III-1
			mm					
1976	June 8 to Sept. 26 (110 days)	seasonal total	452.0	431.9	220.0	818.5	523.5	327.5
		daily rate	4.1	3.9	2.0	7.4	4.8	3.0
1977	June 4 to Sept. 27 (115 days)	seasonal total	467.0	467.5	146.0	820.5	509.5	314.0
		daily rate	4.1	4.1	1.3	7.1	4.4	2.7

Over the two seasons of study, the plant growth rate (as indicated by plant height) was measured at 10 day intervals beginning from the date of ET measurements.

The forage yield was determined for the three cuttings as the green and air-dried weight for each lysimeter.

Estimating methods for ET. A summary of the estimating methods selected is given in Table 1, together with their basic parameters.

Measured data. The means of seasonal and daily values of evaporation, evapotranspiration and precipitation for the full period of measurements, which was 5 days shorter in the 1976 season than in the 1977 season, are shown in Table 2 and Fig. 4. The measurement periods differed because of the delay in setting up the experiment in the 1976 season.

The values listed include the evapotranspiration of Berseem clover under shallow (50 cm), medium (100 cm) and deep (150 cm) water table depths. The differences in magnitude of the measured values in the two seasons were attributed to the prevailing climatic conditions and growth factors during each of the growing seasons.

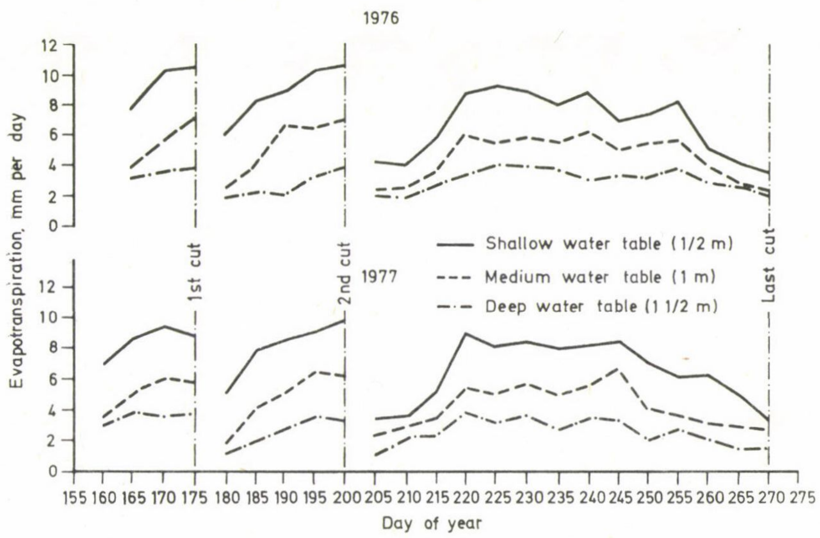

Fig. 4. Daily means of ET (average of 5 days period) at different water table depths

Table 3

Comparison of measured and estimated

Date	Pan evaporation			Measured ET		
	Class A	GGI pan	Christiansen	I-1	II-1	III-1
1976						
June 8–30	133.5	133.4	207.5	191.7	105.0	66.9
July	146.5	156.0	215.2	230.4	147.0	79.4
August	126.0	96.8	130.6	250.9	169.5	105.0
September 1–26	46.0	45.7	50.2	145.5	102.0	72.7
Total season	452.0	431.9	603.5	818.5	523.5	324.0
1977						
June 4–30	123.5	116.0	176.0	201.4	115.0	79.0
July	141.5	135.0	218.6	214.0	135.0	78.8
August	102.5	112.0	156.3	249.8	162.8	101.6
September 1–27	99.5	104.5	78.1	155.3	93.7	54.6
Total season	467.0	467.5	629.0	820.5	505.5	314.0
Average for the two seasons	459.5	449.5	616.3	819.5	514.5	319.0

The data illustrated in Table 2 and Fig. 4 indicate an almost straight-line relationship between Berseem clover evapotranspiration and water table depths.

Comparing the three water table levels, it appeared that plants grown under a shallow water table (50 cm) have the highest seasonal amount and daily rate of ET, whereas the intermediate and lowest values were obtained from medium (100 cm) and deep (150 cm) water tables, respectively. Bennett *et al.* (1964) and Doss *et al.* (1962) indicated that ET rates decreased at different soil moisture regimes as the amount of available water decreased.

The data also showed that the evapotranspiration of Berseem clover under all water table levels increased as the stage of growth and the season progressed, almost until the end of the season when it tended to decrease as the plants became older.

Similarly, it is apparent that the water table may be considered as a source of water, as indicated by Szalóky (1974) and Gilbert—Chambles (1959).

The growth rate, as indicated by plant height (Fig. 5), and the green and air-dried yield from the cuttings (Fig. 6) follow the trend of the evapotranspiration results. The highest and lowest growth rates and yields were obtained from plants grown under shallow and deep water tables, respectively. This may be due to the fact that under a shallow water table the plants had good growth conditions because of the nearness of the available water, with good aeration conditions caused by the continuous drainage of excess water by water supply regulating instruments. By contrast, under a deep water table the amount of rainfall received together with the very deep water table and capillary fringe could not provide the conditions which assure adequate growth rate and consequently cutting yield. At the same time, it was apparent that Berseem clover plants grown under a medium water table depth (100 cm) had intermediate values for growth rate and green and air-dried yield.

evaporation and evapotranspiration

Estimated ET					
Jensen—Haise ET_p	Modified J. H. ET_p	Antal ET_p	Hargreaves ET_p	Petrasovits $ET_{opt.}$	Christiansen ET_a
153.4	120.0	133.1	129.6	161.7	165.3
172.8	135.2	136.2	145.3	135.3	172.2
117.4	94.1	96.4	105.7	84.9	104.5
55.4	44.2	42.8	53.4	25.1	40.2
499.0	393.5	408.5	434.0	407.0	482.2
144.2	112.5	129.5	120.9	117.8	140.8
159.3	125.5	129.0	140.0	124.0	172.9
140.9	110.7	115.3	124.2	104.6	125.0
69.1	56.1	75.9	66.9	49.1	62.5
513.5	405.0	449.5	452.0	395.5	503.2
506.3	399.3	429.0	443.0	401.3	492.7

Estimating ET rates. In order to see how the formulae for estimating ET agree with the actual measured data for different water table depths, monthly and seasonal totals of evaporation and ET were estimated by several formulae which make use of measured climatic variables.

Some of these formulae were used to estimate the pan evaporation and others to estimate potential, optimal and actual evapotranspiration.

All comparisons with the measured data were made by showing the difference as a percentage of the average of totals for the two seasons, as shown in Table 3 and Fig. 7. Pan evaporation comparisons showed that CHRISTIANSEN's (1968) formula (formula 6) overestimates this value for the two pan types, class A pan and GGI pan, by about 34% and 37%, respectively. Moreover, Christiansen's formula requires a great deal of variable climatic data input. These results agree with those obtained by BURMAN (1976).

Regarding evapotranspiration, each of the different ET formulae underestimates the ET of plants grown under a shallow water table (50 cm) by an average of 45%, with individual variations of 38 to 51% for different formulae. These differences may be due in part to the vigorous growth of plants under a shallow water table as a result of the nearness of the water table and the aeration conditions caused by the water supply regulating instruments, which drain water in excess of the field capacity. This vigorous growth, accompanied by a large leaf area per land unit, may have used more water than was used by similar or other crops when the estimating formulae were derived or evaluated, as indicated by JENSEN—HAISE (1963), TOVEY (1969), HARGREAVES (1977b) and KRUSE—HAISE (1974). Another possibility for the difference between estimated and measured ET values under a shallow water table, is the small surface area of the recommended surface area of 1—2 m^2, which is considered to be a good evapotranspirometer area in the report of the Hungarian National Committee on ET (ANTAL *et al.* 1977).

HARGREAVES (1977a) indicated that small lysimeters give ET values which are too high, and HARROLD (1966) showed that the lysimeter walls may introduce a large unnatural effect if the lysimeter area is small.

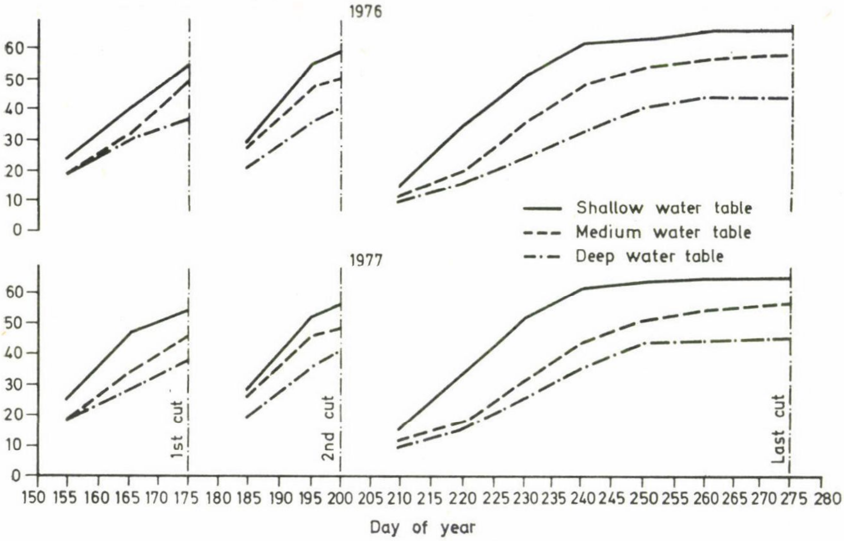

Fig. 5. Plant height at different water table depths in seasons 1976 and 1977

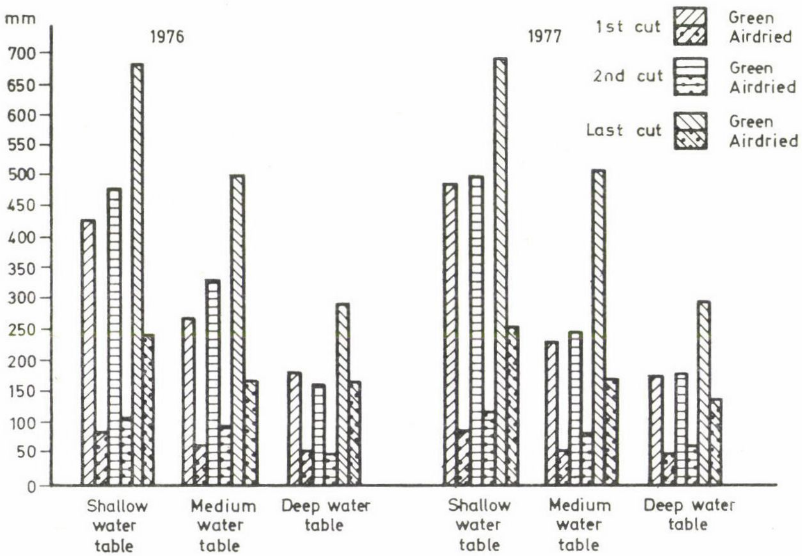

Fig. 6. Green and air-dried yield at different water table depths in seasons 1976 and 1977

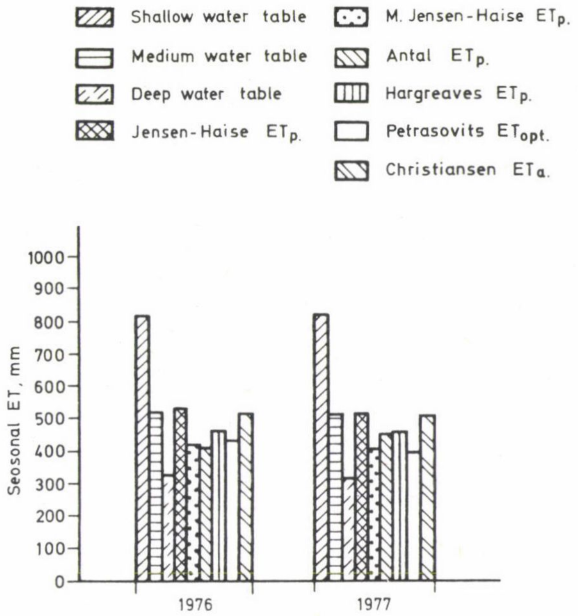

Fig. 7. Measured and estimated seasonal ET

Medium water table depth (100 cm) comparisons showed that the Jensen—Haise formula (formula 1) and the Christiansen formula (formula 7) gave seasonal values which were lower by an average of 3% than the measured values; these were thus considered to be identical. The values obtained from other equations, however, were generally lower by an average of about 19%, with individual values varying from 14 to 22%.

Generally, it can be noticed that each of the estimating formulae gave seasonal average values lower by an average of 13% than the measured values for the medium water table depth, which indicates that the amount of rainfall received in a small lysimeter with a 100 cm water table depth and a large wall area provides soil water conditions which are nearly identical to those used in deriving or evaluating some of the ET formulae.

On the other hand, when comparing deep water table depth (150 cm) ET values, it appeared that the estimating formulae overestimated it by an average of about 40%. This indicated that the amount of rainfall received in addition to the capillary fringe of the deep water table was not enough to maintain the soil water in the condition assumed or used in deriving some of the ET formulae.

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TOTAL CHLOROPHYLL CONTENT OF WEEDS AS AFFECTED BY A TRIAZINE AND A PHENOXY HERBICIDE AND ITS USAGE AS AN INDEX OF BIOMASS OF WEEDS IN THE TREATED PLOTS

An attempt has been made to correlate the chlorophyll content of weeds with the biomass (dry matter production) of the weeds per unit area, in order to make use of the total chlorophyll content as an index of biomass of the total weeds in the herbicide treated plots. A significant correlation has been observed with both the herbicides, between the two above-mentioned parameters. Other results and discussion are presented in the paper.

Chlorophyll is thought to be the principal pigment involved in triazine phytotoxicity in plants (Ashton 1965). Reduction in chlorophyll content due to phenoxy herbicides also has been reported earlier (Williams—Daun 1961). The use of chlorophyll content as an index of productivity of natural communities has been emphasised by several workers (Odum *et al.* 1958, Bray 1960, Mall *et al.* 1973). In the present investigations the effect of a phenoxy and a triazine herbicide on the chlorophyll content of the weeds has been studied and an attempt has been made to correlate the chlorophyll content of the weeds with the dry matter per unit area, in order to make use of the total chlorophyll content as an index of the dry matter production of the weeds in the herbicide treated plots.

Table 1a

Total chlorophyll content of weeds fifteen days after post-emergence treatment with Bladex*

Name of the Weed	Control (Unsprayed plots)	Total chlorophyll content of weeds from plots sprayed with dosage rate of		
		1/2 kg/ha	1 kg/ha	2 kg/ha
Chenopodium album L.	2.1739	1.6545	1.0325	0.6316
Convolvulus arvensis L.	3.0434	2.1040	1.4562	0.9760
Cynodon dactylon Pers.	2.8260	2.2682	1.6050	1.0950
Launia mudicaulis HK	1.5013	1.1340	0.7462	0.5321
Melilotus alba Lamk.	2.7160	1.8340	0.9835	0.5231
Sonchus arvensis L.	1.4492	0.9842	0.7851	0.4675

* mg/g fresh weight.

Table 1b

Analysis of variance. Bladex

Source	D.F.	S.S.	M.S.	F. Ratio	Table F. Value
Weeds	5	3.8294	0.7658	13.56*	4.69
Treatments	3	8.5186	2.8395	49.90*	5.42
Error	15	0.8536	0.0569		
Total	23	13.2016			

* Significant at 1% level.

The present experiments were conducted at Ujjain (23°11′N Lat. and 75°43′E Long.) during the year 1975, in November and December. The mean maximum and minimum temperatures of the area at the time of the investigations are 29.5 °C and 7.7 °C. An irrigated wheat (*Triticum durum* Var. Malavaraj) field at Govt. Seed Multiplication Farm, Ujjain, heavily infested with weeds, was selected for the study. Two herbicides are selected for study, namely

1) 2,4-Dichlorophenoxy acetic acid (pure compound) of the phenoxy group, and
2) Bladex 50% W.P. (2-)4-Chloro-6-ethyl-amino-1,3,5-triazine-2-yl-amino(-2-methyl-propionitrile) (Cyanazine) of the triazine group.

The applications were made with a knapsack sprayer when the crop (wheat cv. Malavraj) was 3 weeks old. The spray volume was 500 l/ha. The herbicides were sprayed along with iso-paraffin oil as surfactant (100 l/ha) at three dosage rates, i.e. 1/2 kg/ha, 1 kg/ha and 2 kg/ha. All treatments and undisturbed controls were replicated three times in a randomised block design. The results presented in the tables are the means of all three replicates. The size of each plot was 2 × 5 metres, with a one-metre wide weed-free space left between adjacent plots. Precautions were taken to prevent herbicidal drift from one plot to another during sprayings.

For chlorophyll estimation, leaf samples (preferably the 4th leaf from the top in all cases) from the treated plots were brought to the laboratory after a fortnight and the total chlorophyll content was measured in 80% acetone extracts, with a spectrocolorimeter at

Table 2a

Total chlorophyll content of weeds fifteen days after post-emergence treatment with 2,4-D*

Name of the weed	Control (Unsprayed plots)	Total chlorophyll content of weeds from plots sprayed with dosage rate of		
		1/2 kg/ha	1 kg/ha	2 kg/ha
Chenopodium album L.	2.1739	1.9815	1.8243	1.3426
Convolvulus arvensis L.	3.0434	2.9354	2.4310	1.9045
Cynodon dactylon Pers.	2.8260	2.7890	2.3125	2.0120
Launia mudicaulis H. K.	1.5013	1.4049	1.2015	1.0216
Melilotus alba Lamk.	2.7160	2.4320	1.9025	1.7235
Sonchus arvensis L.	1.4492	1.4113	1.1214	0.9342

* mg/g fresh weight.

Table 2b

Analysis of variance. 2,4-D. Total chlorophyll content

Source	D.F.	S.S.	M.S.	F. Ratio	Table F. Value
Weeds	5	6.8613	1.3722	14.83*	4.69
Treatment	3	2.3331	7.7770	84.07*	5.42
Error	15	1.3886	0.0925		
Total	23	10.5830			

* Significant at 1% level.

Table 3

The biomass of weeds (g/m²) one month after post-emergence treatment with Bladex and 2,4-D

Dosage rate, kg/ha	Bladex	2,4-D
0.5	86.7	85.6
1	54.3	49.3
2	21.3	18.2
Control	124.1	

Table 3a

Analysis of variance: Biomass of weeds in plots sprayed with 2,4-D

Source	D.F.	S.S.	M.S.	F. Ratio	Table F. Value
Blocks	2	28.26	14.13	4.8^{NS}	10.92
Treatment	3	19,142.94	6,380.98	2,207.95*	9.78
Error	6	17.39	2.89		
Total	11	19,188.59			

* Significant at 1% level. CD = 3.64. NS: not significant.

Table 3b

Analysis of variance: Biomass of weeds in plots sprayed with Bladex

Source	D.F.	S.S.	M.S.	F. Ratio	Table F. Value
Blocks	2	74.34	37.17	3.24^{NS}	10.92
Treatment	3	17,755.15	5,918.38	515.98*	9.78
Error	6	68.84	11.47		
Total	11	17,898.33			

* Significant at 1% level. CD = 7.24. NS: not significant.

652 nm and the amount of total chlorophyll content was calculated using the equation of Dexbury and Yentch.

For aboveground biomass studies, the aboveground parts of weeds from three, 1 m² areas of each plot were harvested and dried at 80°C for 48 hours and the weight was noted. The mean was calculated for each dosage treatment and represented as g/m² in the table. In addition to the chlorophyll and biomass, in order to see the correlation between the two, the mean of the total chlorophyll content of all the weeds at each dosage treatment was taken and correlated with the biomass of the weeds of the same treatments.

The total chlorophyll content as influenced by Bladex treatments are presented in Table 1. Of all the weeds, the maximum reduction in total chlorophyll content was found in *Melilotus alba* Lamk., i.e. 32.4, 63.7 and 80% was observed at dosage rates of 1/2, 1 and 2 kg/ha respectively. In *Chenopodium album* L. reductions of 23.8, 52.5 and 71.7% were observed, while in *Convolvulus arvensis* L. 30.4, 52.5 and 67.9% reductions were observed at 1/2, 1 and 2 kg/ha respectively. *Cynodon dactylon* Pers. showed the least reduction, i.e. 19.4, 43.2 and 61.2% respectively for the 1/2, 1 and 2 kg/ha treatments.

The effect of 2,4-D on the total chlorophyll content of the weeds is shown in Table 2. All the dicot weeds, namely, *Melilotus atba*, *Convolvulus arvensis*, *Chenopodium album*, *Sonchus arvensis* and *Launea mudicaulis*, are susceptible to 2,4-D. *Melilotus alba* showed 10.4, 29.9 and 36.5% reduction in chlorophyll content in the 1/2, 1 and 2 kg/ha treatments, respectively. *Convolvulus* showed 3.5, 20.1 and 37.4% reduction in the same treatments. Cynodon dactylon showed comparatively less reduction in chlorophyll content, i.e. 1.3, 18.1 and 28.7% respectively at 1/2, 1 and 2 kg/ha. The overall results suggest that in comparison to Bladex, with 2,4-D less reduction in chlorophyll content occurred.

As far as the reduction in the biomass of the weeds (Table 3) is concerned, reductions of 30.3, 56.3 and 82.7% were observed with Bladex and 31.2, 49.3 and 85.3% with 2,4-D at 1/2, 1 and 2 kg/ha dosages respectively. The results were found to be statistically significant.

While studying the mode of action of phenoxy herbicides KEY—SHANNON (1964), BASLER—NAKASAWA (1961) and CHEN *et al.* (1972) revealed that the malformations, suppression of growth and necrosis resulting in the death of the weeds due to these herbicides is due to the abnormal stimulation of nucleic acid and protein synthesis. The present study reveals that all the abnormalities will lead to the destruction of chlorophyll as suggested by WILLIAMS—

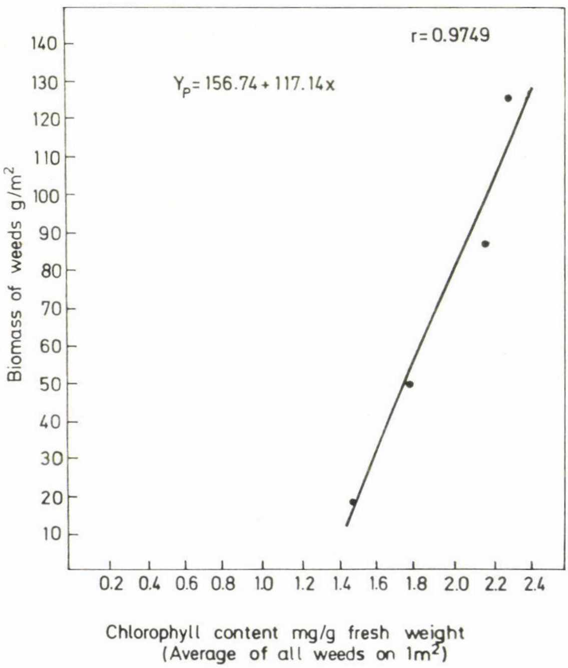

Fig. 1. Relation between chlorophyll and biomass of the weeds of 2,4-D treated plots. The regression line was fitted by calculation

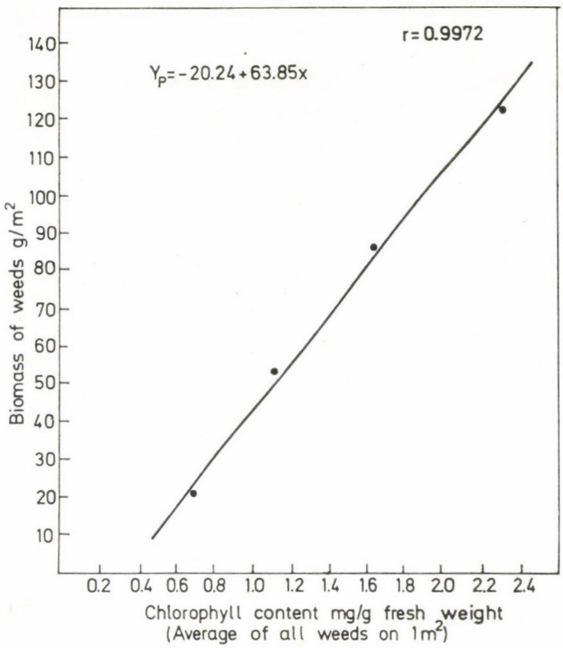

Fig. 2. Relation between chlorophyll and biomass of the weeds of Bladex treated plots. The regression line was fitted by calculation

Daun (1961) and Rao—Dubey (1976) and thus the photosynthesis capacity of the weeds will be lost and induced senescence of the leaves and roots (Kerney—Koufman 1975), i.e. the organs responsible for obtaining energy and nutrient requirements from the environment, will occur, which is a major factor contributing to the death of the plants. Thus reduction in the biomass of the weeds can be attributed to the combined effects, which start from malformations and a reduction in chlorophyll content.

As far as the reduction in the biomass due to Bladex, a triazine herbicide, is concerned, it is mainly due to the effect of triazine herbicides on photosynthesis (Ashton—Crafts 1973). Our present results indicate that the effect on photosynthesis was mainly due to the effect of this herbicide on the chlorophyll content, thus supporting the view of Ashton (1965).

In the present paper an attempt has been made to correlate the chlorophyll content and the dry matter content of the weeds. For this purpose the average chlorophyll content of all the weeds present in one square metre was taken and correlated with the biomass of the weeds per square metre. A significant correlation was obtained with both the herbicides: r for 2,4-D $= +0.9749$ (Fig. 1) and for Bladex $= +0.9972$ (Fig. 2).

Thus the results indicate that the chlorophyll content can be taken as an indicator of the biomass or dry matter productivity of the weeds in the herbicide treated plots. Further, it may be said that a detailed study of this conclusion with other herbicides in these two groups (phenoxy and triazine) will reveal its wide applicability.

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THE SUITABLE PROTEIN LEVEL FOR FEEDING DAIRY CATTLE

III. RELATIONSHIP BETWEEN RUMEN METABOLISM, BLOOD CONSTITUENTS AND MILK COMPOSITION

The dependence of ruminants on rumen microbial activity is very interesting. Any food eaten by a ruminant is immediately subjected to microbial fermentation in the rumen. It seems probable that changes in the food would cause significant changes in the microbial activity, which in turn might affect the host.

Carbohydrates in the rumen are mainly fermented to acetic, propionic and butyric acids which are readily absorped (ANNISON—LEWIS 1959). The effect of a protein-rich ration on the molar percentages of volatile fatty acids in the rumen have been investigated in sheep and in dairy cows. These rations have been shown to increase the molar proportion of butyric and branched-chain acids in the rumen.

Approximately 60% of the variation in milk fat content during the change of diet was associated with the change in propionic acid. Moreover, other workers suggested that the propionate produced in the rumen and carried through the portal circulation to the liver may control the degradation and synthesis of amino acids at this site (ROOK—STORRY 1964). An increase in propionate in the rumen caused a milk protein increase by improving the supply of amino acids to the mammary gland (HUBER—BOMAN 1966).

Since the rations used in these trials differ in protein content, the distribution of nitrogen in the rumen liquor and blood serum was studied. Also, the total concentration of volatile fatty acids and the molar percentages of the individual fatty acids were determined. The composition of the milk was also determined in an attempt to find the relationship between rumen metabolism, blood composition and milk constituents.

Three milk production trials using the swing-over design were undertaken with 15 lactating and non-pregnant Jersey cows to study the effect of feeding different levels of protein on milk production and composition, some blood constituents and rumen activity. The first trial included six cows, while the second and third trials consisted of 5 and 4 cows respectively. The different protein levels used were 182 and 154% of milk protein in Trial I, 182 and 133.3% of milk protein in Trial II, and 182 and 125% of milk protein in Trial III. The system of feeding and the feeding value of the mixtures used are found in Part II of this experimental series (ABD EL-HAFIZ *et al.* 1980).

For each cow a representative composite milk sample from two successive daily milkings (4 successive evening and morning milkings) was taken at the beginning of the test period and then every two weeks.

Milk fat and total solids (T.S.) were determined as recommended by the A.O.A.C. (1960). Total nitrogen was determined by the Kjeldahl method recommended by OGG *et al.* (1948). Milk solids-not-fat (S.N.F.) and lactose were calculated from differences.

Blood samples were taken from each cow by puncturing the jugular vein. The samples were taken at 8 a.m., immediately before morning feeding, at the beginning and end of the test periods. The blood serum was prepared by centrifuging it for 30 min. at 3000/min. The total nitrogen (T.N.) and NPN of the blood serum were determined by the Kjeldahl method, using 10% trichloracetic acid for separating true protein. Urea-N was determined gasometrically by the method of Coversky (PETROONKINA 1961).

Two animals in each trial were equipped with permanent rumen fistula to study the effect of protein level intake on rumen activity. Rumen samples were withdrawn through the fistula before feeding and 2, 4 and 6 hours after feeding. The samples were first strained through two layers of cheese cloth. The pH value was determined using a Beckman pH-meter immediately after straining. Ammonia-N was estimated by the method of CONWAY (1957). Total nitrogen was determined by the micro-Kjeldahl method. NPN was measured by precipitating the protein in the liquor using 10% (w/v) trichloroacetic acid. Total volatile fatty acids were determined by steam distillation as described by WARNER (1964). The individual volatile fatty acids in the samples taken before and 4 hours after feeding was determined using a silica gel column after BULLEN *et al.* (1952) as modified by EL-SHAZLY *et al.* (1963).

The statistical analyses were carried out according to SNEDECOR (1962).

Rumen activity. The results in Table 1 indicate that in all treatments the highest pH values were obtained before feeding, and the lowest ones 4—6 hours after feeding. The differences between the periods were highly significant ($P < 0.01$). Similar results were reported by FONNESBECK *et al.* (1970).

These data also showed that the variations in digestible crude protein intakes caused no substantial differences in the rumen pH values. This may be due to the fact that the regulation of the pH in the rumen mainly takes place by the addition of alkali to the animal ingesta through the flow of saliva and through the elimination of fatty acids from the rumen by absorption and the buffering action of the rumen ingesta (ANNISON—LEWIS 1959).

Table 1

Effect of feeding different protein levels to lactating Jersey cows on rumen constituents

D.C.P. intake periods[1]	182%*	154%*	133.3%	125%*	Mean of time**
			pH values		
P_1	7.0	6.9	7.0	6.9	6.88 ± 0.21
P_2	6.35	6.45	6.4	6.35	6.35 ± 0.12
P_3	5.8	5.9	5.9	5.95	5.88 ± 0.08^a
P_4	6.15	5.85	5.8	6.0	5.93 ± 0.20^a
Mean of treatments	6.33 ± 0.47^A	6.28 ± 0.46^A	6.13 ± 0.46	6.3 ± 0.41^A	
			Total nitrogen (mg/100 cc)		
P_1	190.5	119.5	105	108	130.8 ± 40.3^a
P_2	185.5	115.0	104	91	123.9 ± 42.2^a
P_3	246.5	187.5	148	140	180.5 ± 48.7
P_4	287.0	257.5	191	158	223.4 ± 59.3
Mean of treatments	227.4 ± 48.4	169.8 ± 67.6	138.8 ± 41.4^a	124.3 ± 30.3^a	
			Ammonia N (mg/100 cc)		
P_1	10.3	9.55	9.50	10.45	9.95 ± 0.81^{ab}
P_2	11.9	9.95	9.05	8.25	9.79 ± 1.54^a
P_3	15.1	12.45	11.25	8.6	11.85 ± 2.72^c
P_4	14.7	11.6	9.65	7.95	10.99 ± 2.77^{bc}
Mean of treatments	13.01 ± 2.17	10.89 ± 1.57^A	9.86 ± 1.03^A	8.81 ± 1.41	
D.C.P. intake periods[1]	182%	154%	133.3%	125%	Mean of time
			Total V.F.A. (mg/100 cc)		
P_1	7.35	5.05	6.25	5.05	5.9 ± 1.44
P_2	10.6	7.65	6.50	3.80	7.1 ± 2.67^a
P_3	11.85	9.15	8.85	5.75	8.9 ± 2.58^b
P_4	12.00	7.6	5.30	5.55	7.6 ± 3.51^{ab}
Mean of treatments	10.45 ± 1.65	7.36 ± 2.98	6.7 ± 0.92^A	5.04 ± 1.85^A	
			N.P.N. (mg/100 cc)		
P_1	83.5	73.5	56.0	66.0	69.8 ± 11.6
P_2	87.5	63.0	45.5	55.0	62.8 ± 18.0
P_3	111.0	91.0	70.0	59.5	82.9 ± 22.9
P_4	119.5	105.0	80.5	70.0	93.5 ± 22.6
Mean of treatments	100.4 ± 17.6	83.1 ± 18.6	63.15 ± 0.4^a	62.6 ± 6.7^a	

[1] D.C.P. intake calculated as a percentage of milk protein.

* The values are the mean for two cows.

** Means within a column and row in each constituent not followed by the same letter are significantly different at the 5% level according to Duncan's multiple range test.

Table 2

Effect of feeding different protein levels to Jersey cows on individual fatty acids (acetic C_2, propionic C_3, and butyric C_4)

Acids	Control level		Test level					
			Trial I		Trial II		Trial III	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
C_2	71.7	71.4	71.6	71.5	69.6	69.2	71.6	70.7
C_3	19.8	20.0	21.8	21.6	21.5	21.5	21.7	21.2
C_4	8.6	8.7	6.8	6.9	8.9	9.3	6.8	8.1
C_2/C_3	3.62	3.57	3.28	3.31	3.24	3.22	3.30	3.33

P_1 = sample taken before feeding.
P_2 = sample taken 4 hours after feeding.

Table 3

Analysis of variance to test differences in individual volatile fatty acids

S.V.	D.F.	S.S.	M.S.
Treatment (T)	3	4.36	1.45
Acids (A)	2	7363.81	3681.9**
Times (P)	1	0.85	0.85
TxP	3	2.71	0.903
TxA	6	22.75	3.79
PxA	2	0.42	0.21
Error	6	3.60	0.60
Total	23	7397.56	

** Significant at 1% level.

In respect of the total concentration of volatile fatty acids (VFA), the results in Table 1 indicate that the concentration was significantly ($P < 0.01$) higher at the highest level of protein intake (control) and decreased gradually with decreasing protein intake. Bath—Rook (1963) reported that protein intake significantly affected the VFA concentration of the rumen. These results may be due to some ingested protein being degraded in the rumen and serving to supply the nitrogen requirements of the micro-organisms which ferment the dietary carbohydrate. However, the breakdown of excessive amounts of protein to VFA and ammonia is wasteful to the nitrogen economy of the animal and may be harmful, especially if large amounts of ammonia are rapidly produced (Annison—Lewis 1959).

Changes in the molar proportions of the individual fatty acids and the acetic/propionic acid ratio are shown in Table 2. Analysis of variance on these results (Table 3) showed that there are no significant differences in the molar percentages of the fatty acids due to variations in the level of protein intake. In this connection, Cross *et al.* (1974) found that there were no differences in the molar percentages of acetic, butyric, valeric and iso-valeric acids when animals consumed either 85 or 100% of the NATIONAL RESEARCH COUNCIL (1970) recommendations for crude protein.

Moreover, the acetic/propionic acid ratio was the lowest in Trial II and the highest in the control, yet these ratios did not differ greatly from one treatment to another.

The concentration of T.N. in the rumen (Table 1) increased significantly as the D.C.P. intake increased from 125 to 182% of milk protein. Several workers (HUME *et al.* 1970, ABD EL-HAFIZE 1973) reported that the T.N. concentration in rumen liquor increased in response to N-intake.

In addition, it could be noticed that the concentrations of T.N. were higher before feeding than after 2 hours of feeding. This may be due to the higher concentration of micro-organisms in the rumen before feeding than two hours later (FAHMY 1975). The highest values of T.N. were found 6 hours after feeding at all levels. Yet the rise in T.N. after feeding became faster as the protein level of the diet increased. This relatively sharp increase in ruminal-N suggested that the N-components of the diet with the highest protein content were rapidly assimilated in the rumen from the coarse particles of food to either particles of small size or soluble forms of N (ELLIOT—TOPPS 1964).

The data concerning NPN and ammonia-N concentrations in Table 1 show that the values of the two parameters increased significantly ($P < 0.01$) with increasing protein intake. This means that at low levels of protein, the rumen micro-organisms use the major part of the food protein to build their cells (WALDO 1968). Also, ABD EL-HAFIZ *et al.* (1980) found that the average ammonia-N content was positively and linearly related to the nitrogen of the given food ($r = 0.888$).

Table 4

Effect of feeding different protein levels to lactating Jersey cows on some blood constituents

Item	Initial control			Test level			Final control		
	S_1	S_2	Average	S_1	S_2	Average	S_1	S_2	Average
Trial I									
T.P., g	7.7	7.5	7.5	7.4	6.6	7.0	6.5	7.0	6.75
N.P.N., mg	114.3	132.9	123.6	130.2	100.9	115.55	116.0	122.2	119.1
Urea, mg	32.8	31.0	31.9	28.8	29.0	28.9	29.8	30.6	30.2
Trial II									
T.P., g	6.8	7.6	7.2	6.1	6.8	6.45	7.4	7.8	7.6
N.P.N., mg	81.4	107.9	94.65	85.7	81.9	83.8	110.8	75.2	93.0
Urea, mg	30.3	30.8	30.55	22.7	24.7	23.7	32.0	231.8	31.91
Trial III									
T.P., g	8.2	8.3	8.25	6.5	7.9	7.2	6.6	6.9	6.75
N.P.N., mg	107.7	107.7	107.7	119.5	115.6	117.55	123.5	103.6	113.55
Urea, mg	18.7	23.8	21.25	24.4	23.0	23.7	22.8	20.5	21.65

Note:

S_1 = sample taken one month after the start of the trial.
S_2 = sample taken at the end of the trial period.

Table 5

Effect of feeding different protein levels to lactating Jersey cows on milk composition

Item		Trial I			Trial II			Trial III		
		Initial control	Test level	Final control	Initial control	Test level	Final control	Initial control	Test level	Final control
Milk yield		4.7	3.6	2.3	4.9	4.9	4.5	5.9	3.7	3.0
Protein	x	3.80	4.20	4.40	3.90	3.90	3.90	4.00	4.10	4.40
	±	0.21	0.43	0.43	0.22	0.54	0.27	0.29	0.27	0.36
Fat, %	x	4.7	5.6	6.2	4.6	4.7	5.0	4.0	4.3	4.5
	±	0.32	0.78	0.71	0.45	0.66	0.72	0.47	0.71	0.34
T.S., %	x	12.2	13.6	14.7	12.5	12.9	13.4	11.8	11.7	12.3
	±	1.0	0.85	1.45	0.65	1.33	0.64	0.38	1.8	0.53
S.N.F., %	x	7.5	8.0	8.5	7.9	8.2	8.4	7.8	7.4	7.8
	±	0.8	0.63	1.2	0.54	0.86	0.62	0.27	0.66	0.3
Lactose, %	x	2.7	3.8	4.10	4.00	4.30	4.50	3.80	3.30	3.30
	±	0.84	0.72	0.87	0.40	0.34	0.44	0.00	0.80	0.20
Ash, %	x	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	±	0.05	0.07	0.07	0.03	0.06	0.05	0.05	0.08	0.04

Blood constituents. The effect of feeding different digestible crude protein levels on some blood constituents is found in Table 4. It could be noticed that reducing the level of intake from 182 to 154% of milk protein did not affect the constituents of the blood serum.

However, reducing the protein intake from 182 to 133.3% of milk protein caused a decrease in T.N., NPN and urea-N, and these decreases were statistically significant ($P < 0.05$) except in the case of T.N. In this connection, Huber—Boman (1966) and Darwish (1973) found that increasing the D.C.P. level in the diet had no significant effect on total serum protein, but significantly increased the NPN and urea-N of the blood. Moreover, Lewis (1955) reported that changes in the diet lead to different levels of blood urea concentration which can be correlated with different rumen ammonia concentrations.

On the other hand, reducing the protein intake to 125% of milk protein increased NPN and urea-N, but the increase was only statistically significant in the case of urea-N. This may be explained by the fact that the 125% level of milk protein was lower than the level required for milk production. Accordingly, tissues may be catabolized to compensate for the deficiency of protein in the tested ration. Therefore, the amino fraction may be lost as urea-N.

Milk composition. When studying the effect of protein intake on milk composition, it was decided to compare the percentage change in each fraction during the three periods of each trial. The average milk compositions in the three trials are found in Table 5. There is a slight change in the percentage of milk protein. These changes in the percentage of protein were associated with the natural milk decrease. The negligible differences in milk protein due to changes in protein intake may be explained by the fact that all the rations offered were calculated to cover the energy requirements of the animals. PAQUAY *et al.* (1973) reported that the amount of N secreted in the milk depended above all on the metabolizable energy intake and the stage of lactation. There was no significant difference in the molar percentage of propionic acid between the treatments. In this connection, several workers (ROOK 1959, ROOK—STORRY 1964) reported that the propionate produced in the rumen and carried via the portal circulation to the liver may control the degradation and synthesis of amino acids at this site. Moreover, HUBER—BOMAN (1966) reported that an increase in propionate in the rumen increased milk protein by improving the amino acid supply to the mammary gland.

The results in Table 5 also show that variation in the D.C.P. intake from 125 to 133.3%, or 154 to 182% of milk protein had no significant effect on the milk fat percentage. Similarly, HASSAN—RUSSEL (1975) and TREACHER *et al.* (1976) reported that increasing the digestible protein level in the diet had no effect on the fat percentage. This may be due to the fact that approximately 60% of the variation in milk fat content during the change in diet was associated with the increase in propionic acid. Therefore, the slight differences in the molar percentage of fatty acids due to the treatments only caused insignificant differences in the fat content of the milk.

It is clear from the results in Table 5 that the level of D.C.P. in the ration had no significant effect on the S.N.F. and lactose content of the milk. WRIGHT *et al.* (1974) reported that the S.N.F. and lactose content of milk were affected mainly by the energy level intake. Therefore, maintaining the energy intake of the animals during different intervals of the experimental periods caused insignificant differences in the S.N.F. and lactose percentages when feeding different levels of D.C.P..

The data in Table 5 also reveal that the differences in T.S. percentage between the treatments were insignificant. This may be explained by the fact that the T.S. content gave a measure of the cumulative effect of the treatments on the individual milk constituents.

Generally, it could be concluded that when the energy level intake was high enough to meet the requirements of the animals and was kept constant, and when the molar percentages of acetic and propionic acids in the rumen were not changed, the variation in the level of D.C.P. intake had no substantial effect on the milk composition.

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PHYSIOLOGY OF PRESOWING SOAKING OF SEEDS OF VIGNA RADIATA (L.) WILEZEK

II. ANALYSIS OF FACTORS INDUCING NEGATIVE RESPONSE FOLLOWING SEED SOAKING

The electrical conductivity and the quantity of free amino acids and sugars in the seed diffusate collected after soaking *Vigna radiata* (L.) Wilezek seeds in water, increased

Table 1

Germination percentage and germination relative index of Vigna radiata

Batches	Seed condition and germination media**	Germination, %								
I	(unsoaked control) WC/DW	83.3								
		Soaking periodicity (cycles)								
		I			II			III		
		Soaking duration (hr)								
		1	3	6	1	3	6	1	3	6
II	WC/DW	76.6	46.6	23.3	66.0	53.0	20.0	56.0	0	0
III	WC/DF	83.3	86.6	80.0	86.6	76.6	70.0	76.6	40.0	33.3
IV	WOC/DF	80.0	86.6	83.3	90.0	83.3	73.3	73.3	33.3	26.6

* Diffusates were collected from seeds soaked in water at 30 ± 1 °C for 1, 2 and 3 cycles of 1, 3 and 6 hrs each.

** WC — Seeds germinated with coats. WOC — Seeds germinated without coats.

with the increase in soaking duration and cycles and this resulted in a reduction in germination and in the germination relative index.

The presowing soaking of seeds in water induces resistance against drought in crops (Delis *et al.* 1972, Vega *et al.* 1972, Woodruff 1973), except for certain species which show a negative response (Husain *et al.* 1968, Salim—Glenn 1968). Hypotheses regarding the negative response of presowing soaking treatments reveal oxygen deficiency and the accumulation of carbon dioxide in the soaking media (Kidd—West 1919), leaching out of soluble metabolites during soaking (Eyster 1940, Wheeler 1965, Hobbs—Obendorf 1972, Adebona—Odu 1972) and damage to the meristematic tissue of the seed (Berrie 1960, Harrison 1973). This communication reports a detailed analysis of the seed diffusate of *Vigna radiata* cultivar G-65, with special reference to amino acids and sugars in relation to the magnitude of the negative response to presowing soaking treatments following seed soaking.

Healthy seeds obtained from the Department of Plant Breeding, Punjab Agricultural University, Ludhiana, were soaked in water for 1, 3 and 6 hr under sterilized conditions and then air dried to the original seed moisture percentage, repeating the sequence up to a maximum of three times, which represents three cycles of soaking and drying. Diffusates were collected from 300 seeds at 30 ± 1 °C and the final volume was made up to 75 ml with water. The specific conductivity of the diffusate was measured on a conductivity bridge. 35 ml of the diffusate was dried and dissolved in 3 ml of 20% ethyl alcohol and analysed for sugars and amino acids using the single dimensional paper chromatography method with butanol : acetic acid : water (4 : 1 : 5 v/v) as the solvent system (Srivastava—Sharma 1973). Seeds given soaking treatments (damaged seeds discarded) and with (WC) and without (WOC) seed coat were germinated in Petri dishes lined with blotting paper moistened with the respective diffusates (10 ml) at 30 ± 1 °C. The final germination percentage and the germination relative index (GRI) were calculated (Srivastava—Sareen 1972) based on a 72 hrs observation. All the experiments were replicated three times.

*seeds planted in distilled water (DW) and seed diffusate (DF)**

Germination relative index
67.7

Soaking periodicity (cycles)								
I			II			III		
Soaking duration (hr)								
1	3	6	1	3	6	1	3	6
61.0	39.0	17.0	49.0	42.0	15.0	40.0	0	0
70.0	71.0	68.0	72.0	74.0	61.0	64.0	24.0	20.0
64.0	74.0	72.0	76.0	74.0	63.0	64.0	22.0	17.0

The data collected indicate a remarkable reduction in germination and GRI after the soaking of seeds in water and this reduction was magnified with the increase in the duration and the number of cycles of soaking (Table 1). There was a high increase in individual free amino acids and sugars assayed chromatographically with the increase in soaking duration and cycles, amounting to a total relative increase of about 3900% amino acids and 57% sugars after 6 hr of soaking in three cycles, as compared to 1 hr soaking in one cycle (Table 2). No specific situation arose where a single amino acid or sugar showed behaviour different to the other twelve free amino acids and three sugars assayed, except for a continuous increase in their quantity in the diffusate with the increasing duration of soaking. The leaching out of soluble metabolites like amino acids and sugars appeared to have a definite relationship with the germination of *Vigna radiata* seeds. The increase in the specific conductivity of the diffusate with the increase in soaking duration (Table 2) confirms the loss of permeability of the membrane as a cause for the reduction in germination rather than any of the other reasons proposed so far by earlier workers (Kidd—West 1919, Berrie 1960, Harrison 1973, Perry—Harrison 1970), including oxygen deficiency and damage to the seeds. Earlier works regarding the increase in electrical conductivity and the leaching out of soluble metabolites with the increase in soaking duration (Eyster 1940, Hobbs—Obendorf 1972) as the cause for the deleterious effect on the growth of plants find more supporting evidence from the data collected in the present investigation with *Vigna radiata*. The data collected to show that the use of soaking media (DF) as the germination media gives more germination than those germinated in water (DW) (Table 1) fully confirm the fact that it is the leaching out of the metabolites which prepares the conditions for reduced germination rather than any of the other reasons suggested so far. The other possibilities cannot be ruled out, but the leaching out of metabolites has been provided with more solid proof in this experiment.

The other aspect of the problem, as suggested by Orphanos—Heydecker (1968), according to which seed coat hardening following presowing seed soaking leads to decreased germination, does not appear to have any relevance to the present finding, as the removal of the testa (WOC) did not improve germination compared to seed used with the testa (WC), even when the germination media was supplemented with various seed diffusates, so as to provide optimum conditions for better germination. In some cases seeds without coats (WOC)

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Table 2

Quantitative estimation of (a) free amino acids (μg), (b) sugars (μg) and (c) electrical conductivity (mhos/cm) in seed diffusate collected by soaking 300 seeds of Vigna radiata in water for 1, 3 and 6 hrs each in 1, 2 and 3 cycles

	Periodicity of soaking (cycles)								
	I			II			III		
	Soaking duration (hr)								
	1	3	6	1	3	6	1	3	6
a) Cystine, Cystein	57.87	135.03	167.18	77.1	527.26	1,414.60	77.16	617.50	1,601.52
Glutamic acid	59.156	118.62	180.04	115.0	270.06	677.44	165.00	337.24	1,774.68
Aspartic acid	51.44	231.48	328.60	186.4	237.91	643.10	192.90	411.52	1,388.88
Glycine, Serine	77.16	379.37	977.36	194.4	784.46	1,363.16	141.46	868.72	1,480.24
Arginine	64.30	353.65	617.28	141.4	817.281	812.752	141.46	924.92	1,208.84
Proline		102.88	141.46	90.0	192.90	977.36	225.72	591.56	1,363.16
Phenylalanine		90.02	794.46	115.0	501.54	2,161.98	125.02	540.12	2,713.46
Tyrosine		57.87	64.30	38.6	167.18	334.36	57.87	282.92	797.32
Alanine				12.8	64.30	231.48	154.32	591.56	334.36
Valine, Methionine		45.01	51.44		77.16	154.32	102.88	231.48	244.36
Total amino acids	309.926	1,513.93	3,322.12	885.7	3,640.051	8,767.552	1,383.79	5,404.54	11,906.82
b) Sucrose	231.48	296.45	565.84	527.26	739.45	1,279.57	845.55	1,126.56	1,464.20
Glucose	85.13	227.93	147.46	192.90	231.48	149.46	252.10	295.56	455.60
Fructose	90.02	56.80	302.88	94.36	102.88	122.17	231.05	235.73	353.54
Total sugars	406.63	581.18	1,010.08	814.52	1,073.81	1,551.20	1,329.70	1,657.85	2,279.34
c) Electrical conductivity	233.3	350.5	466.6	258.3	790.5	899.0	300.0	1,205.0	1,333.3

gave relatively better germination and GRI, though the increase was negligible and inconsistent, but there is a consistent decrease after 3 and 6 hrs of soaking in three cycles. This makes it very evident that seed coat removal does not influence the deleterious effect of presowing soaking treatment on germination.

To support the hypothesis that the leaching out of metabolites is the cause of the deleterious effect on seed germination and plant growth observed following presowing soaking, more conclusive evidence with regard to the change in the membrane configuration for the leaching of metabolites must be worked out.

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FORUM

OUR GUEST IS

DR. ALADÁR SIPOS

DIRECTOR OF THE INSTITUTE OF ECONOMICS,
HUNGARIAN ACADEMY OF SCIENCES

PÁL, GY.: *Sir!*

In many cases capitalist countries with a high level of industrialization cover even their fundamental food requirements from countries where more than 70% of the population is under-nourished. In 1960 one Argentinian consumed as much meat as 50 Indians, 20 Japanese, 5 Italians or 2 Austrians. And in countries where there is chronic starvation (Venezuela, Ecuador, Colombia, Peru, Suriname) the calory content of the diet does not even reach a daily value of 1500. In your opinion, should the fight against hunger concentrate on developing agricultural production or on reducing the population growth rate?

SIPOS, A.: The fact that nutritional problems exist in the world is no novelty. The roots of the problem go very deep, and are primarily of social origin. I think the solution to this problem, which affects the whole human race, is extremely complex; it will require a whole series of measures taken in wide international co-operation. Certain progress — though not much — has recently been made in this respect, but the fight against hunger is substantially more difficult now than it was earlier, mainly because in some parts of Africa, Asia and Latin America the number of poor people is increasing. Nearly one and a half thousand million people earn less than 200 dollars a year. At least half of them live in extreme poverty, under conditions which offend human dignity.

According to the most recent estimates by FAO, in the market-oriented developing countries alone, more than 400 million people (22% of the population) do not get the necessary daily amount of calories. The number of people whose daily diet lacks the necessary proteins, vitamins, mineral salts, etc., i.e. who do not consume the right quality of food, is much higher than that.

The world production of food has increased in the seventies. The average rate of growth in the developing countries has exceeded that of the developed capitalist countries, but this covers substantial differences in the rate of growth between the countries. On the whole, however, the per capita food production has increased at a slower rate in the seventies than in the previous five years. In Africa a decrease of 1.4% has occurred, while in the Near East, in Asia and South America the growth has been 1.4, 0.2 and 0.5%, respectively. In other words, the increase in food production has hardly, if at all, kept pace with the increase in population. This explains the fact that for great masses of people the catastrophic nutritional stituation has not improved. The basic precondition for improvement is to *increase* agricultural *production*, i.e. to create the conditions necessary for the development of villages and agriculture. Luckily there are wide possibilities of increasing agricultural production. Considering the forces of production available in world agriculture and the vast reserves of the developing countries the idea of exploiting these possibilities is not Utopian.

The growth of agricultural production in the developing countries can be achieved both by extending the production area and by increasing the yields. In these countries the per ha yields of major foodstuffs such as wheat, barley, rice and potatoes do not amount to even half of those in the developed countries.

The fertilizer utilization per unit area in the developing countries is estimated to have been an average of around 20 kg in the seventies. But in Africa barely 4 kg and in the Far East only about 17 kg fertilizer was distributed per hectare. It is common knowledge that the industrially developed countries use many times as much. The developing countries cover nearly half of their fertilizer requirements from imports, so it is extremely important for them to increase their production of fertilizers, considering the well-known financial difficulties.

Losses in agricultural produce must be reduced in the developing countries. At present substantial losses are caused in food production by diseases, pests and weeds which attack field crops. The losses are estimated to be 30%, or even 50% in certain crops.

Harvesting losses are also significant, as well as those occurring during transportation and storage.

An increase in food production postulates the wide utilization of scientific and technical achievements.

If the necessary conditions are to be brought about, a *thorough* transformation of the *socio-economic* structure is needed; the present system of *income distribution* must be changed.

An indispensable precondition for social progress is to carry out radical *land reform* whereby the land will belong to those who cultivate it. The land reforms carried out so far have not satisfied this requirements. According to a FAO publication, for example, in one Latin American region in 1965 93% of the land was owned by 7% of the landowners. Ten years later 15% of the land was distributed among the peasants, but only one-fifth of the claims were satisfied. Seventy per cent of the population of Latin America (85 million people) continue to live under miserable conditions despite the land reforms which have been carried out in different countries. Of these 85 million people, 45 million are employed as seasonal workers on the large estates, the owners of which represented some 2% of the population but owned 47% of the land in 1973.

However, land reform alone cannot bring about an upswing in agricultural production, unless it is coupled with other measures. Expensive investments, for example, call for credit.

In order to increase food production in the developing countries the governments will have to pay greater attention to the development of agriculture. Industrialization must be co-ordinated with the development of agriculture.

I think therefore that the best way to fight against hunger is to improve agricultural production. However, it is also necessary to control the increase in population. This is again a complex problem, which is closely connected, above all, with general economic and social progress. The rapid rate of urbanization, the increasing employment of women, systematic family planning and extensive explanatory campaigns will all lead to a reduction in population growth to an acceptable level.

*

PÁL, GY.: *Owing to structural changes in the national economy of West European countries the contribution of agriculture to the national income and the number of people employed in agriculture are decreasing. The technological interdependency makes the co-ordination of marketing necessary, followed by a technical co-ordination of production. The same processes can be observed in the agriculture of the socialist countries. Do you think that at a certain stage in the development of agricultural production the same laws necessarily operate in the capitalist and socialist countries ?*

SIPOS, A.: A structural change in the national economy can be observed not only in Western Europe, but also in the socialist countries. This is natural if we consider that so far the vast majority of countries where socialist revolutions have been successful have been economically underdeveloped. In these countries large-scale industries had to be developed from scratch, since this is a precondition of socialism. This is also the only way to overcome the backwardness of agriculture. In Hungary, for example, the national income has increased more than fivefold over the last 35 years compared to the level before World War II. An important role in this has been played by the more than tenfold increase in industrial production during the period in question. The rise in agricultural production has naturally been slower. Today, however, the agriculture of Hungary produces nearly 70% more than the pre-war level, with half the labour force and on a smaller area. As a result of this development the production structure of the national economy has considerably changed, with a shift in the proportions of the different branches. Industry has assumed outstanding importance in ensuring economic growth and in achieving social policy objectives. The distribution of labour has changed accordingly. Before World War II more than half of the country's work-force was employed in agriculture; this proportion is at present about 17% and the shift in proportion is expected to continue in the future, too.

This process can partly be explained by the fact that the demand for food, now that the elementary needs have been satisfied, does not rise proportionately with the increase in real income. Instead, consumption patterns are changing: parallel with a decrease in the consumption of cereals the demand for foodstuffs rich in proteins and vitamins is growing. At a higher stage of economic development this tendency is characteristic of both the capitalist and the socialist countries.

The reduction in the absolute number of people employed in agriculture is, however, related primarily with the technical development and industrialization of agriculture. As a consequence of the rapid development of productive forces over the last twenty years the technical basis of agriculture in the socialist countries has undergone a considerable change; mass production has gained ground in an increasing number of agricultural branches. Manual work is gradually being replaced by machines. In more and more countries agriculture, or at least certain branches of it, are passing from the manual to the mechanical phase. In Hungarian agriculture, for example, mechanical traction power amounted to 14.4% of the total traction power in 1950 and 50.2% in 1960, while this proportion is now nearly 100%.

The mechanization of agriculture, and of crop production in particular, has now reached a high level in Hungary. Soil cultivation, sowing and plant tending are almost completely mechanized, though not always in accordance with the modern requirements. Considerable results have been attained in the mechanization of harvesting: cereal and maize harvesting and potato lifting are now a hundred per cent mechanized. Sugar-beet harvesting is also almost fully mechanized.

The mechanization of animal husbandry, with the exception of poultry and egg production, has not yet reached the level achieved in crop production, but there is rapid development in this field, too.

Technical progress necessarily involves increased specialization and a greater division of labour, which makes co-operation and combination indispensable in production. If the high-powered tractors and machinery produced by industry are to be utilized economically, there must be an increase in farm size and production volume, because this is the only way for up-to-date farming equipment to be fully exploited. It can thus be said that the concentration and specialization of farming are processes associated with the development of productive forces. This explains the progress in horizontal integration in both capitalism and socialism. The essence and consequences of this are, however, different in the two social systems.

Another very important characteristic of this development is that traditional agriculture is becoming just one link in the food production chain, which is made up of many component parts: agricultural production is becoming the raw material producing branch of the food industry, and this not only stimulates the concentration of agricultural production, but also necessitates the establishment of new forms of co-operation (integration). The deepening of relations between agriculture and the branches which precede and follow it requires closer co-ordination of the activities of different food production verticums.

It must also be taken into consideration that mass production is gaining ground not only in the production of agricultural final products beyond the bounds of agriculture, but also within agriculture itself. In these vertically interconnected but operatively separate processes of agriculture, the whole production of each unit in a particular phase is simultaneously the raw material of the next phase, until ultimately it becomes an agricultural final product.

The technological interdependence developing between the individual verticums necessitates not only the co-ordination of marketing but also the technical co-ordination of production. At a certain stage of development this necessity is characteristic of both socialism and capitalism.

This all leads to the conclusion that if the productive forces are at an identical level of development the structure of the economy shows many similar features even in radically different social systems. Integration and the technical co-ordination of production are also necessitated by the more or less identical development levels of the productive forces. Thus, apart from the specific laws characteristic of the given social form alone, there are others that can be detected in a number of societies. It must be emphasized, however, that these differ greatly in content and in the way they are manifested.

In the developed capitalist countries vertical integration based on contracts is the main form of agro-industrial integration.

As regards form this means that decisions concerning the different phases of food production are concentrated in the hands of an integrator, who is one of those participating in the process. As to its content, on the other hand, vertical integration is simply the integration of agriculture into large-scale industry and trade, since the vertical integration of agriculture is characterized by the co-ordination of the activities of units with very diverse economic capacities. Small farms, whose economic capacity is much lower than that of industry, are faced with highly centralized industrial and commercial enterprises. Consequently, the conditions cannot be dictated by agriculture. If the relative positions of those participating in the vertical integration are considered, it becomes evident that it is agriculture itself which will be integrated.

In short: in capitalist countries, although vertical integration promotes the development and spread of large-scale farming, this organization of the reproduction process ensures the dominance of large industrial enterprises over agriculture. The farmers are highly restricted in what decisions they can take, and the reins of farm management gradually slip through their fingers, until their economic stituation hardly differs from that of hired workers. Thus, vertical integration greatly increases the dependence of farmers on capital, thus destroying any illusions of peasant independence.

In the socialist countries the socio-economic conditions for the industrialization of agriculture and agro-industrial integration are much more favourable.

During a certain phase in the building of socialism the socialist transformation of agricultural production, which was then based on small farms, was an objective necessity. This process took place at the initiative of the socialist state, with a simultaneous improvement in the agricultural production forces which were subsidized in various ways, thus removing the obstacle put in the way of their development by the fragmented structure of agriculture. Today in most European socialist countries the development of agriculture takes place on a large scale, based on state and co-operative farms. In countries where this process is complete socialist production conditions prevail. State and co-operative ownership are both socialist ownership of the same type, which excludes the possibility of dominance and subordination in their relationship. The connections and integration between industrial, commercial and agricultural enterprises are based on equal rights and mutual advantages and risks, which is in the interest of the whole society.

Naturally these advantages do not develop automatically in the different verticums of food production; they necessitate many-sided, conscious social action on the part of both the central authorities and the enterprises themselves.

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Pál, Gy.: *In the United States 702 million dollars (5.8% of the net agricultural income) was spent on subsidizing agriculture in 1960. In 1970 these price subsidies had reached 3800 million dollars, 22.9% of the net agricultural income. The net agricultural income decreases from year to year, however, because the prices of the goods and machinery purchased by agriculture are rising faster than the prices paid to farmers for agricultural products. In your opinion, will agriculture in Hungary be capable of developing without state subsidization if prices are fixed at their true value ?*

Sipos, A.: The trends mentioned in the question prevailed in the agriculture of the United States from 1948 to the early seventies. Due to the extension of foreign markets and increases in world market prices the net agricultural income rose substantially between 1970 and 1974, as shown by the data in Table 1.

Table 1

Trend of agricultural net income in the United States of America (thousand million dollars)

Year	Net income
1948	17.7
1950	13.6
1960	11.5
1970	14.2
1971	14.6
1972	18.7
1973	33.3
1974	26.1
1975	24.5
1976	18.8
1977	20.5

Source: Economic Report of the President. Washington, 1979. p. 287.

The table shows that American farmers earned outstandingly high incomes in 1973. Since then, however, incomes have again shown a decreasing tendency, in spite of an increase in agricultural production. The reason why the net agricultural income has decreased is that the prices of goods bought by the farmers are increasing at a faster rate than the purchase prices for agricultural products.

The state subsidization of agricultural production is a world-wide phenomenon. It is impossible to discuss the reasons for this in detail, but it should be emphasized that the state agricultural policy changes according to need. Basically, it is aimed at encouraging or restricting production, improving the structure of agriculture, raising its technological level, raising agricultural incomes and controlling the markets.

Taking all this into consideration I do not think that Hungarian agriculture could manage without state subsidization either, especially as Hungary exports large quantities of food and has to compete on the world market with countries where agriculture is heavily subsidized.

The state subsidization of agriculture depends fundamentally on what price centre is chosen. If the purchase prices of agricultural produce were determined on the basis of investments made by farms operating under the worst conditions, then the financial basis for independent management would certainly be provided for every agricultural enterprise. Such a rise in the price level would, however, raise a number of problems. In order to maintain a balance between producer and consumer prices the level of the latter would have to be raised substantially. Furthermore, in a considerable proportion of the farms extremely high profits would be made. As a consequence, a system of profit withdrawal would have to be applied, which would cause an adverse effect in well-managed farms. Taking all things into consideration, since the price level cannot be adjusted to the production of farms working under unfavourable conditions, the system of state subsidization must be maintained.

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Pál, Gy.: *In Hungary there were 214 state farms and agricultural combinates in 1965, 184 in 1970, 150 in 1975, 146 in 1976 and 141 in 1977; the number of co-operatives in the same years was: 3278, 2441, 1598, 1470 and 1425. With the reduction in the number of agricultural enterprises the average size of those remaining has increased. Do you think the amalgamation of co-operative farms, the fusion of state farms, and the establishment of production systems have promoted vertical or horizontal integration in Hungary?*

Sipos, A.: To start with, the amalgamation of co-operative farms and the fusion of state farms promoted horizontal integration. The vertical expansion and improvement of large-scale farm management started simultaneously and is still continuing today. This means that increasing the volume of specifically agricultural products is no longer the only task of the state and co-operative farms; they are also expected to improve the relevant industrial services and develop their food processing and marketing activities. These activities are based on the ever increasing volume of products turned out by the highly mechanized and specialized large-scale farms within the production systems. If production is to be efficient, in agriculture as in industry, industrial repair and servicing units, which are indispensable for turning out finished products, will be required, together with internal co-operation. At the same time, the production of large volumes of raw food material makes it not only possible but also necessary (to an extent varying from one branch to another) for the large farms to process and even sell some or all of their produce themselves. In other words, the management of a large-scale farm now includes all the economic activities (machine, repair, construction, maintenance, processing, transportation) that are indispensable preconditions of progressive reproduction within the vertical system of food production. In this way the vertical co-operation within large-scale farms is extended, resulting, among other things, in the evolution of new social and economic formations. These include the agricultural combinates, for example, whose work is no longer restricted to crop production and animal husbandry, but, as the result of internal development, takes in industrial activity as well. The combinates functioning in Hungary at present have developed from state farms with vertically organized activities. In fact, combination characterizes the activities of many more agricultural enterprises than are officially recognized as combinates.

A new form of vertical integration is represented by the agro-industrial associations, which involve vertical cooperation both within and between enterprises. In Hungary four experimental agro-industrial associations have recently been established. The industrial and agricultural enterprises participating in them remain independent.

As for the production systems, they represent, in my opinion, the main path to industrialization in Hungarian agriculture.

Before classifying the production systems according to the nature of the integration, I will give a brief summary of their essential features.

To start with, the progress of industrialization in agriculture renders the optimum combination of production factors increasingly necessary, and this, in turn, requires a system-oriented view. This means that in organizing production the production process as a whole must be taken as the starting point. If this view is taken the character of technical development will totally change and integration will come into prominence as opposed to differentiation. The earlier phases of agricultural industrialization in Hungary were characterized by the fact that one or another factor contributing to yield increase (mechanization, chemicalization, plant breeding) alternately came into prominence with a view to developing production. The system-oriented view, on the other hand, is characterized by the joint consideration of all factors acting in production:

technical, biological, chemical and human factors are brought into harmony on a solid scientific basis. So in all phases of the production process the most up-to-date production factors (high yielding varieties, machines, pesticides, feed, labour force, etc.) are applied in a complex manner. In the technological system developed through the close co-ordination of these factors all tasks are strictly defined and programmed. In Hungary this purpose is served by the production systems. These production systems or organizations are justifiably compared to industry, as the concentration, organization and programming of production, the standard of organization and the technological discipline are comparable to that in a well organized industrial plant.

In the production systems all production factors are equally important, because if any one of them fails to reach the prescribed level the success of the whole operation is jeopardized. The connection between the production factors is controlled by technological standards. It is therefore extremely important to maintain technological discipline, as even a minor deviation from this upsets the balance between the production factors, thus endangering the efficient operation of the system. All this raises new demands on the professional knowledge of the workers.

The introduction of production systems necessarily involves increased specialization in the farms and the concentration of production. The optimum exploitation of large-scale machinery is only possible if the farm area is sufficiently large, and livestock units must also reach a certain size before they can be managed economically.

The production systems produce large quantities of goods. This necessitates the close co-ordination of production, storage and processing. The production systems raise the standard of vertical relations within the farms, e.g. the relation between fodder production and animal husbandry. In addition, under the influence of the production systems an increasing role is played by vertical integration, by the co-ordination of the successive processes of end-product production, and by the integrated direction of the various phases of food production: harvesting, processing and marketing.

In many cases the introduction of production systems results in a new type of labour division between the farms. At the present stage of development a considerable proportion of the large farms are not yet able to elaborate such systems. This explains the fact that farms which have elaborated a technology for the large-scale production of one or more products become the centres of the production systems. In Hungary these are called system centres or system hosts. In principle any large farm can work out a production system for a given product, but state recognition is necessary before the system can be set up. Thus, no farm has a monopoly, and several farms may compete in setting up production systems for the same products. Experience shows that in Hungary competition has played, and will continue to play, a very important role in the spreading of production systems and in the achievement of results. Each would-be participant has the opportunity to consider the conditions and the advantages offered, and to decide on this basis whether or not to join the system. Under such conditions every large-scale farm is able to enjoy the advantages offered by concentration, specialization, up-to-date techniques and management principles on a voluntary basis, without the loss of independence, because the system centre cooperates in the organization of production in the member farms, elaborates and improves the production technology and adapts it to the conditions of the member farms, provides various services, and checks that the correct technology is followed.

The production systems are generally involved in co-ordinating similar activities, e.g. the production of wheat, rice, maize, sugar-beet, etc. In this sense the production systems can be regarded as cases of horizontal integration. In addition to this, however, the signs of vertical integration can also be detected in them. This is evident in the work of the system centres mentioned above, as well as in the fact that in some production systems the system centre is an industrial enterprise, not a farm. This is the case, for example, with the Integrated Sugar Production System at Petőháza, the Hemp Production System in Szeged, and the Alkaloida Chemical System. It can thus be said, that in Hungary horizontal and vertical integration are intertwined in practice.

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PÁL, GY.: *In the state farms and co-operatives the average monthly wages of those employed as full-time workers amounted to 1978 Ft in 1970, 2826 Ft in 1975, 2968 Ft in 1976 and 3193 Ft in 1977, while the number of active agricultural earners was 1193.7, 1039.0, 1008.6 and 988.3 thousand, respectively, in the same years. Do you think the increase in the per capita income of the agricultural population is due to the reduction in numbers or to the higher profitability of farming ?*

SIPOS, A.: The increase in the per capita income of the agricultural population in Hungary is the result of the joint action of several factors. Mention should first be made of the growth of agricultural production and commodity production, and the higher productivity of manual labour.

Before the socialist reorganization of agriculture the agricultural production of Hungary showed considerable annual fluctuations, while the growth rate was only moderate. After the setting up and stabilization of large farms had begun, the rise in production became more balanced and proceeded at a faster rate. The average annual growth rate for gross agricultural production was 1.5% between 1951 and 1961, 1.8% between 1962 and 1965, 2.8% in the period 1966—1970 and 4.8% in 1971—1975; in the first three years of the current five-year plan it was 3%. The net production value of agriculture increased by 0.8% a year between 1966 and 1970 and 6.7% a year between 1971 and 1973.

The rise in the per capita income of agricultural workers has been promoted by the extension of the activities of large-scale farms. This process began after the introduction of the new system of economic management in 1968, and led to a more uniform attitude and to the development of healthy tendencies at the beginning of the seventies. Previously even the simplest industrial activity closely related with agriculture was illegal. The reform put an end to these restrictions, and industrial work connected with agricultural production and the processing of agricultural produce was initiated in the large-scale farms. In this way the subsidiary activities of large-scale farms have been greatly extended since 1968. In 1968 16% of the returns from sales in the large-scale farms came from subsidiary activities; 75% of this originated from farming and servicing activities, 10% from processing, and 15% from direct marketing. In the co-operative farms alone incomes originating from subsidiary activities rose by 60% between 1968 and 1970, and the ratio of this income to the total returns from sales rose from 13 to 18%. This change in the production structure of large-scale farms, extending the scope of activity, has had a favourable effect on employment, thereby resulting in an increase in the gross income.

The continual increase in the state purchase price for agricultural produce has also had some part in the rise in incomes. For example, the price index for state purchase prices rose by 17% from 1966 to 1970 and by 11.7% between 1971 and 1974. There was a simultaneous increase in the price index for agricultural implements of industrial origin and in the consumer price index for agricultural workers. The increase in these indices was far lower, however, than the rise in state purchase prices (1.6%

between 1966 and 1970, 8.2% from 1971 to 1974); so this only limited the increase in personal incomes to a moderate extent.

Various forms of state subsidization have also contributed to the rise in the incomes of co-operative farm workers, particularly the subsidies given to farms with unfavourable site and economic conditions, and the investment and farm management subsidies. The latter have been of assistance chiefly by increasing the accumulation fund and decreasing the production costs. The price and income subsidies granted to farms with unfavourable conditions have also increased the incomes directly.

Finally, a certain role in the rise in incomes has naturally been played by the fact that the increasing proportion of the gross income (which has also increased as a consequence of the factors mentioned) which can be spent on personal incomes is distributed among a decreasing number of workers. It must be emphasized, however, that while the number of active agricultural earners has decreased, the amount of work done by the members of co-operative farms has increased. Between 1966 and 1970, for instance, the total working time accomplished in the collective farms of the co-operatives increased by 10%, and the number of (10-hour) work-days calculated per co-operative member rose by 14%.

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PÁL, GY.: *In 1974 97,900 new members joined the co-operative farms in Hungary. Thirty per cent of these were young people and housewives, 17.1% came from other farms, and nearly half of them (48.8%) came from other branches of the national economy. In your opinion, is the increase in the number of co-operative workers as the present generation gives way to the next due to "restratification", or to the fact that former agricultural workers are returning from industry, and do you consider restratification favourable from a production and social point of view ?*

SIPOS, A.: The increasing number of people joining the co-operative farms during the present passing from one generation to the next reflects both a "restratification" and the return of some of the former agricultural workers. The process can be fundamentally explained as follows: On the one hand, decisive changes occurred in the living standards of agricultural workers by the end of the sixties, because the income level reached that of industrial workers, as shown by the data in Table 2.

According to the data in the table, changes in the ratio of the total income of industrial workers to that of agricultural workers were caused by the fact that the incomes of agricultural workers rose more rapidly than those of industrial workers. The difference in the rate of growth reached a maximum in 1973 and later declined.

On the other hand, as a consequence of the industrialization of agriculture the character of agricultural work has changed considerably and the demand for skilled labour has increased. Accordingly, in 1978 there were three times as many university-trained experts, and twice as many middle grade specialists in the co-operative farms as in 1970.

Finally, the extension of subsidiary activities in the large-scale farms must also be taken into consideration, since this again creates new possibilities of employment.

As I see it, restratification is a positive process from production and social points of view alike, because industrialized agriculture requires increasingly well qualified workers. Otherwise the economic efficiency of agricultural production can hardly be increased. Highly qualified professionals are, however, in short supply in the co-operative farms even today. There is a serious shortage of experts in farm

Table 2

Total annual per capita incomes of industrial and agricultural workers in Hungary (forints)

Year	Industrial workers	Agricultural workers	Income ratio of agricultural workers (industrial workers = 100)
1965	13.983	13.028	93
1966	14.951	14.082	94
1967	15.798	15.416	98
1968	16.500	16.750	102
1969	17.630	17.950	102
1970	18.972	19.711	104
1971	20.031	21.152	106
1972	21.274	22.556	106
1973	23.164	24.763	107
1974	25.397	26.643	105
1975[a]	27.500	28.500	103–104

Source: József Bálint: Társadalmunk rétegződése és a jövedelemarányok a statisztika tükrében (Social stratification and income ratios as reflected by statistics in Hungary). Társadalmi Szemle, 1976. No. 4, p. 44.

[a] Preliminary data.

organization, mechanization, finance and accountancy. This shortage can hardly be made up from among the older generation.

I should like to emphasize that special attention should be paid in Hungary to the development of agriculture and the food industry, as agricultural production and the food industry will continue to play an outstanding role in raising the standard of living. The natural conditions in Hungary make it possible to supply the population with practically all the important foodstuffs from domestic production. The provision of a quantitatively and qualitatively balanced food supply presents a challenge not only to agriculture but to the processing industry and marketing as well. In addition, agriculture must also be considered as a producer of raw materials, since, in addition to the food industry, certain light industries process raw materials mostly of Hungarian origin.

Nor should it be forgotten that Hungarian agriculture is capable of much more than just covering the domestic requirements. Food exports could be increased, so food production should be developed in such as way as to promote an increase in foreign exchange income. This makes it imperative to ease the tension between agricultural production and the processing capacity, and to extend the refrigeration and storage facilities. The food industry should be developed so as to enable agricultural produce to be processed at a higher level, and larger quantities of competitive products to be produced. Large-scale farms could play an important role in this by increasing their processing facilities. This would be of great economic advantage. For example, it is advantageous to process raw materials in the district where they are produced; this improves food supplies to the population in the district concerned and eliminates superfluous transportation, which not only results in a saving in costs, but also prevents the deterioration of raw materials (e.g. meat, milk, etc.).

Finally, within the scope subsidiary activities the large-scale farms supply useful services, which is also a social interest of high priority.

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Pál, Gy.: *The population of peasant towns in the Great Hungarian Plain has not changed for some years; for example, in 1978 the populations of Csongrád (22,000), Hajdúszoboszló (18,000), Hódmezővásárhely (54,000), Karcag (24,000), Kisújszállás (13,000), Makó (30,000), Mezőtúr (22,000), Szentes (34,000) and Túrkeve (11,000) were the same as in 1970. Is the resisting of industry the only way in which these stagnant towns can start redeveloping, or can urban development be the result of progress in agricultural production as well ?*

Sipos, A.: I should not consider these two factors of urban development as alternatives to one another, since from the point of view of development both are important. It is reasonable to exploit the possibilities inherent in the co-operative farms belonging to these towns and to develop large-scale agricultural production, which, as I have mentioned, puts new demands on the agricultural workers as well. This in itself means that the professional structure of the population in these towns must change. Since the co-operative farms in question are mostly of considerable size, and are thus able to turn out large quantities of agricultural products, it might be reasonable to extend their industrial processing activities. This again would create new possibilities of employment. Furthermore, I think that the viewpoint mentioned above, namely that processing units should be located near to the sources of raw material, should be taken into consideration when deciding on the location of the food industry. In this respect there is much to be done.

Industrial units other than those of the food industry could also be introduced, of course. I am thinking here mainly of plants designed to lessen the seasonal character of agricultural employment. There is already a certain amount of industry in these towns. The reconstruction of these plants is another important task.

I do not think it is a tragedy, if the population of a town does not grow at lightning speed. The social motives for settlement concentration should also be carefully considered. In a modern society these urban communities may have a role to play and may be capable of development. After all, the social atmosphere of a town does not depend primarily on the number of inhabitants.

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Pál, Gy.: *Co-operative farms with unfavourable soil and topographic conditions have higher than average costs and produce below-average yields. This is true of approximately one-third of the co-operative farms in Hungary. Some of these may reach the cost and income level of the average farms by adjusting the crop structure, while others may later be gradually liquidated. Could the rise in food prices be stopped by the liquidation of co-operative farms with poor conditions ?*

Sipos, A.: The economic stituation of some 300—400 of the approximately 1500 co-operative farms is permanently unstable; even simple reproduction causes occasional problems. These include not only co-operative farms with unfavourable conditions, but also ones in which the management and the production structure are inadequate. I think that satisfactory perspectives should be offered to these co-operative farms at a national economic level, by combining various branches of production and co-ordinating the regional development plans. This should not be confined either to increasing production at all costs, or to liquidating the farms. Primarily the production structures should be adjusted to suit the conditions. This necessarily involves stagnation or discontinuation in the production of certain products (produce), or the running down of some activities. The facilities thus released can be regrouped according to the new structure. As this sometimes involves redundancy, the problem of employment must also be solved. Some of the labour force released may find employment in the subsidiary enterprises of the co-operative farms, while others may be transferred to other branches of the economy.

As to the second part of the question, I think that the rise in food prices is due to a general price increase caused by inflation, rather than to the standard of production in co-operative farms with poor conditions.

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PÁL, GY.: *With respect to innovation, small and medium industrial enterprises have an advantage due to their rapid adaptation to new technologies and markets, as they are able to respond quickly to the appearance of technical novelties. On the other hand, they are at a disadvantage as they are not properly informed about relevant technical progress, and do not possess the capital and capacity required for the introduction of new techniques. Do you think that farm size determines the extent of innovation in Hungarian agriculture as well?*

SIPOS, A.: The centralization of agriculture in Hungary has continued for the last fifteen years, even after the establishment of large-scale agriculture. The number of state farms decreased from 271 in the early sixties to 134 in 1978 and that of the co-operative farms from 4500 to 1369, while the average farm size increased to 7508 ha for the state farms and from 1190 to 3798 ha for the co-operative farms. This farm size, coupled with adequate management and organization and a greater or lesser rate of specialization, is generally sufficient to provide an adequate basis for the application of up-to-date productive forces, production techniques and management principles, and for the establishment and development of large-scale production. It must also be taken into consideration that in a period of technico-scientific revolution the technical progress is so fast that adjustments in farm size cannot keep pace with it. Under such conditions it is particularly important to realize that the amalgamation of farms is not the only feasible way to concentrate and specialize production. Experience in Hungary and abroad proves that if the farm size does not ensure the economical application and utilization of highly developed technology the various types of association provide an adequate framework within which this contradiction can be resolved. These vertical or horizontal connections between various enterprises, in particular the production systems discussed above, have proved in practice that they are efficient means of innovation. The importance of joint undertakings is increased by the fact that, if the resources of the individual farms prove insufficient, particularly in livestock breeding, the financial means required for establishing production units of optimum size can be provided through association.

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PÁL, GY.: *In the German Federal Republic the number of farms between 1 and 5 ha in size decreased by 644,000, those of 5—10 ha by 190,000, and those of 10—20 ha by 3500 from 1949 to 1971, while the number of farms between 20 and 50 ha increased by 54,300 and those over 50 ha by 5500 during the same period. In the capitalist countries the liquidation of small farms and the establishment of large-scale farms is a historical necessity. Should, in your opinion, the communist parties in the capitalist countries call for land reforms in their agricultural programmes, and can they approve in their agricultural policies of the liquidation of small farms and the establishment of large-scale farms as a progressive phenomenon?*

SIPOS, A.: The call for land reforms is closely connected with the historically evolved agricultural structure of a given country. Until the last few decades, the agricultural development of the capitalist countries was characterized by a very slow rate of concentration. Although the number of small farms has decreased greatly over the last two or three decades, agriculture has shown the lowest rate of concentration of all the branches of production. Thus, in the European capitalist countries, particularly on the continent, the degree of concentration in agriculture is very low, its sectoral structure is highly fractionated and decentralized, and the farms are relatively small. In the European Economic Community, for example, the average farm size is less than 20 ha. Some eighty per cent of the farms cover less than 20 ha, while those larger than this make up only 22% of the total number of farms. In the countries of the Common Market 10 ha is cultivated by one agricultural worker, compared to 136 ha in the United States of America.

There are, of course, considerable differences between the countries in the degree of agricultural concentration. Within the EEC the average farm area is the largest in England (nearly 70 ha) and the smallest in Italy (hardly more than 7 ha). In the German Federal Republic, Belgium and Holland the average farm size is 13—14 ha, i.e. less than the Community average. In Denmark, France, Luxemburg and Ireland, on the other hand, it exceeds the EEC average (22—23 ha). This shows that in spite of the rapid liquidation of small farms the increase in farm size in the developed capitalist countries seems to be too slow to keep abreast with the requirements of technical progress.

It is also due to this structure that the dominant type of farm in the countries in question is the family farm, which does not employ farm labourers. As a consequence of the technical progress of agriculture the proportion of family farms has increased since World War II, because at the present level of technology the amount of land which a peasant family can cultivate and the number of livestock which the family can attend to have grown. As a result of development in the productive forces the ratio of manual to mechanical labour has shifted in favour of the latter, and since the average farm size has not substantially increased some of the labour force has become redundant. Consequently, in many cases the smaller capitalist farms and medium peasant farms no longer employ either permanent or seasonal hired workers, and even in the larger farms fewer labourers are hired. Under these circumstances the communist parties in the developed capitalist countries cannot call for land reforms.

Nevertheless, the communist parties in the developed capitalist countries cannot put themselves in opposition to the objective processes of social progress, and the evolution of large-scale agricultural production, which is required by the development of production forces. Of course, this does not mean that they must approve, as a progressive phenomenon, of the capitalist form of establishing large-scale agricultural production by liquidating hundreds of thousands of family farms. The agricultural policy of the communist parties is designed to protect the family farms. However, the present family farms put restraints on the economic utilization of up-to-date production forces. Under such conditions the agricultural policy of the communist parties should give preference to creating large-scale agriculture by means of co-operatives. This form of centralization is more favourable for agricultural workers than the capitalist form, and enables viable farms to be set up where scientific and technical achievements can be more rationally utilized.

It is obvious, however, that even co-operative farms cannot make satisfactory progress if the size of the farm is not increased. As the level of mechanization increases this factor becomes more and more important. So laws are required to ensure that the land passes into the hands of family or co-operative farms. This means putting an end to land speculation, and making long-term loans at low interest available to farmers to enable them to buy land which is up for sale. The size of family farms could also be increased by the compulsory selling of land by persons whose main occupation is outside agriculture. A similar purpose would be served by the requisition of lands which are left fallow. In addition, social and economic measures should be taken to strengthen the co-operative farms and make them technically well equipped. This would mean putting restraints on big capital, to lessen its influence on agriculture. In a really democratic system co-operative farms could play an important role, representing the starting point for up-to-date agriculture and the most direct form of financial preparation for socialism in agriculture.

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PÁL, GY.: *Thank you for the information.*

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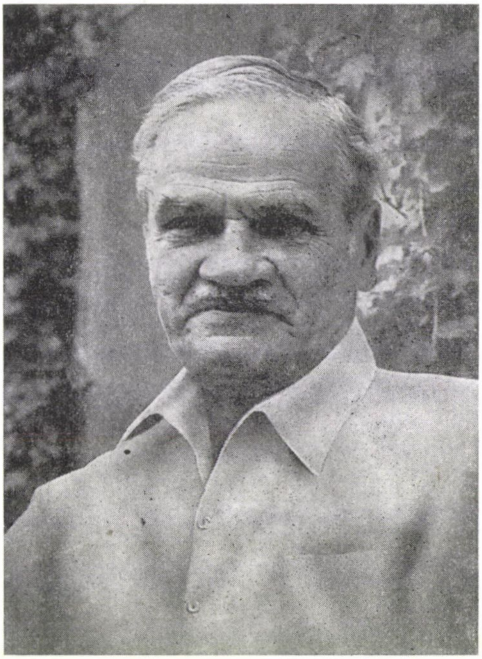
CHRONICA



REZSŐ SOÓ

1903—1980

Rezső Soó, a prominent representative and leading personality of Hungarian and international botanical science, was born on 1st August 1903 in a Székely (East-Transylvanian Hungarian) family at Székelyudvarhely, Transylvania. From his early youth he displayed incomparable energy and ambition in his career. He began collecting plants and stamps at the age of fourteen and was seventeen when his first publication appeared. His high ambitions incessantly urged him to achieve something new. He began his education at Kolozsvár, then attended university in Budapest as a member of the Eötvös College. In 1925 he passed his teacher's examination with honours, and obtained his doctor's degree (in botany, mineralogy and chemistry) summa cum laude. In 1926 he was granted the degree of doctor sub auspiciis for a dissertation which solved the problem of "seasonal polymorphism". He pointed out that in opposition to Wettstein's theory the seasonal polymorphic forms were not the products of agricultural cultivation, but were natural ecotypes.

His monographs on Melanpyrum and Rhinanthus were written on the basis of such considerations (1927, 1970).

His first book was a botanical text-book for Hungarian schools in Transylvania (1926). From 1925 to 1927 Soó was a member of the Collegium Hungaricum in Berlin, worked in the Botanical Institute and Botanical Garden in Dahlem, and held lectures in the Botan. Verein d. Provinz Brandenburg. It was during this period that he began to visit foreign scientific institutes and make botanical excursions.

From 1927 to 1929 he was a research assistant at the Biological Research Institute, Tihany. Carrying out research on the origin of the Hungarian "puszta" he established that in ancient times the Great Hungarian Plain was a forest steppe (1926), now represented by the karstic scrub forests (Orno Cotinion) on the slopes of the Hungarian Central Mountains (1940).

At the end of 1929, at the age of 26, he was offered the chair of botany at Debrecen University, where he organized the Botanical Institute and Botanical Garden of the university. There he had the opportunity to establish a new "school" of coenology and ecology, which soon became known as Soó's coenological school even beyond the borders of Hungary. In 1935 he was officially delegated to the botanical congress in Amsterdam; in 1936—37 he was dean of the Faculty of Arts, and in 1939 a guest professor in Königsberg for six months.

In Debrecen Soó was an active proponent of nature conservation on the Great Hungarian Plain; the establishment of the Bátorliget reservation is linked with his name. As secretary to the Natural Science Section of the Debrecen Scientific Society he was the editor of "Tisia", the journal of the Section, besides editing the institute's own periodical Acta Geobotanica Hungarica (1936—1949).

In the autumn of 1940 Soó was appointed professor of plant taxonomy at Kolozsvár university and at the same time director of the Botanical Garden and Botanical Collection of the Transylvanian Museum. After surviving the siege of Budapest, he returned to Debrecen in the autumn of 1945 to resume his post at the institute. A new series of publications started at Kolozsvár (3 volumes of Scripta Botanica Musei Transsilvanici, 2 volumes of Fontes Florae Hungaricae) was discontinued, but the Acta of the Institute and the Magyar Flóraművek (Hungarian Flora) continued to appear. His university text-book on phytogeography was one of the first works on natural science edited after World War II.

He wrote numerous critical floristic works (Mátra 1937, Székelyföld 1940—43, Mezőség 1947) and was co-author of the Kolozsvár Flora (Nyárády 1941—44). He also made a substantial contribution to the knowledge of the flora of the Trans-Tisza Region, Nyírség (1932—48), Sátorhegység (1940), Bükk (1943), etc.

In 1947 Soó was elected corresponding member of the Hungarian Academy of Sciences. The Academy commissioned him and Sándor Jávorka to compile a manual on the flora of Hungary (1951). This was sub-titled "Taxonomic key and ecological and economic guide to the wild and cultivated plants of Hungary" and was written on the basis of Jávorka's floristic works with the collaboration of other Hungarian botanists. This collective work satisfied a long-felt need for a manual providing complex information on plants, not only for professionals but for all those who dealt with plants in the course of their work. The book enabled them to become acquainted with the wild and cultivated plants of Hungary and with their life conditions, and also contained data on the growth, requirements, cultivation, yield and utilization of trees important in forestry. It indicated the medicinal value of the plants (off. and med.), the names of drugs and how they were used in official and popular therapy, and supplied technical data on the cultivation of certain major medicinal plants. Among the field crops some 190 species grown in Hungary were treated in detail. The descriptions included information on physiological aspects, vegetation period, thousand-grain-weight, seed requirement, germinative ability, sowing, planting, soil requirement, flowering time, pollination, etc. Data were presented on yield, active ingredients and chromosome number, and for some plants a key for identifying species and varieties was also given.

In 1951 Soó was elected a full member of the Academy of Sciences, and was president of the Biological Section in 1952—53. In 1951 he was awarded the Kossuth prize for "his outstanding merit in Hungarian biological research and its organization". He was commissioned by the Ministry of Education to write the text-book "Fejlődéstörténeti Növényrendszertan" (Phylogenetical Plant Taxonomy) for which he was again awarded the Kossuth prize in 1954.

From 1952 to 1955 he also delivered lectures at Budapest University, then from 1955 to 1969 he was head of the Department of Taxonomy and Phytogeography and director of the Botanical Garden at the Eötvös Loránd University.

After preparing syntheses of the vegetation on alkali, sandy and marshy soils (1947—57) he wrote a systematic critical survey of the Pannonian plant communities (1957—63), and described the forests of the Great Plain (in Magyar 1960). Of his numerous taxonomic works his papers on the *Orchideae* are of particular interest; Soó was one of the greatest specialists on European *Orchideae*. In co-authorship with Z. Kárpáti, he published a taxonomic key to the Hungarian flora in 1968.

In 1964 Soó began writing his 6-volume work, covering nearly 4000 pages: "Magyar flóra és vegetáció rendszertani, növényföldrajzi kézikönyve" (Taxonomic and phytogeographic handbook of Hungarian flora and vegetation), the most detailed microsystematical-coenological floristic work in the world literature. It summarizes the results of Hungarian floristic research over several centuries and gives data on the Hungarian flora, broken down according to species in a critical synthesis. Besides wild species it encompasses Hungarian cultivated plants and the major ornamental plants. Cytotaxonomic data, the distribution of the plant in Hungary, ecological conditions (particularly soil requirement), life form, flowering time, biological character of the flower and coenological data are presented for each plant, with additional information on its importance in practice.

Due to illness (mainly heart trouble) Soó completely retired from social and scientific public life after January 1970. On 10th January 1970 he lost his beloved wife who had been his companion on research and study tours, taking photographs of plants and landscapes. It was during his sometimes severe illness that his work "Bibliography of Hungarian Synecological Scientific Literature 1900—1972" was completed with the collaboration of 12 specialists. This work, published in 1978, covers the Hungarian phyto- and zooecological and coenological literature of nearly three-quarters of a century and includes a full list of Hungarian bioclimatological, soil and hydrobiological works. The book contains 5642 numbered literary references, and provides an important review of various fields of science.

Instead of discussing his books and papers in detail, reference can be made to the appreciation published on the occasion of his seventieth birthday.* Here, only a few numerical data will be given to illustrate the wide range of his literary activity. He published 29 books, more than 400 scientific papers, and a large number (some 3000 in all) of reviews, lexicon entries, popular articles, lectures, accounts of travels, etc. His articles and lectures have been published in 7 languages in 16 countries.

In the course of his foreign travel he visited the whole of Europe and also made journeys to Morocco, Egypt, Anatolia, Trans-Caucasus and Soviet Central Asia.

During his successful life he was fully appreciated both at home and abroad. Besides the Hungarian Academy of Sciences the East-German Academia Leopoldino-Caroliniana also elected him a full member (he was a guest professor there for six months). He was an honorary member of the Hungarian Biological Society, the Botanical Section, the Soviet Federal Botanical Society and of Austrian, Finnish, Bavarian, Bulgarian and Swedish associations; he was deputy chairman at a number of international botanical conferences; he was on the editorial bords of 4 foreign scientific reviews, and in addition was

* "Prof. Rezső Soó Academician on his Seventieth Birthday" (Acta Botanica Academiae Scientiarum Hungaricae, Tom. 19/1—4, pp. III—XI, 1973). Besides his biographical data, the paper cites his most important books, journals and serial publications and gives a list of his pupils and of the plants named after him, etc.

honorary member or honorary president of numerous social organizations. Fifty plants have been named after him.

He was twice awarded the gold medal of the Order of Labour. In his seventieth birthday the Kossuth Lajos University of Debrecen conferred an honorary doctor degree on him, and in 1979 he was given the freedom of the city of Debrecen.

His unique botanical activity was equalled by a similarly unique passion for collecting. He presented the herbarium he had compiled from his childhood, which consisted of about 50,000 sheets, to Kolozsvár (now Babeş-Bolyai) University.

He had close associations with literature and the fine arts, as witnessed by his library of more than 10,000 volumes, and a collection of small prints consisting of some 80,000 sheets, the third largest private collection of its kind in the world. He also had a collection of about 170,000 stamps, again one of the largest and most valuable collections of this character in private possession.

Soó often stated that the greatest pride and achievement in his life was not his papers and collections, but the fact that he had established a school and could call 60 or 80 biologists his pupils, many of whom had obtained the very highest scientific qualifications. Not only theoretical biologists but also numerous prominent representatives of agriculture, horticulture and forestry acknowledged him as their master.

He demanded a great deal from his pupils and colleagues, but as well as expecting knowledge and diligence he also appreciated it, and was proud of his colleagues' progress. In his human relations he was incomparable.

The poem "Thanks for Life" by the poet Ady, whom Soó idealized, was a kind of confession of faith for him, which he quoted as follows:

> "Life is a unique pleasure that never recurs,
> it must be enjoyed and finely lived,
> surrounded by fine works"

Living in this way, Professor Soó and his works marked the end of an era in Hungarian botany, paving the way from the floristic to the coeno-ecological period. But his name and memory will survive not only in botany, but also through other parts of his versatile personality and in his collections.

Of himself he said: "My life has been an incessant struggle with myself, my tasks, my environment, with the rapidly flying time and my diminishing strength. But, I must admit, ever since I was a child enormous vanity and ambition have urged me on to achieve, create and collect as much as possible". As to whether he had been successful, he himself gave the answer: "Fate has allowed me to realize the object of my life", and he gave thanks for this in the words of Ady's poem:

> "And whatever will now come
> Before I leave for good
> I shall give my thanks for this".

The end came on 10th February 1980, in the 77th year of his life; and as we take leave of him we too give thanks for the rich inheritance he has left us, which will be a source of knowledge for generations to come.

I. MÁTHÉ

FROM MAGYARÓVÁR TO MARTONVÁSÁR AND HUNGARIAN PLANT BREEDING

When the Martonvásár institute was established in 1949, it was decreed that it should inherit the main task of one of its legal predecessors, the Magyaróvár National Plant Breeding Institute, namely the professional supervision of the plant breeding stations. After the first reorganisation, within about 6 months of its foundation, the professional supervision of the plant breeding stations was still an important part of the activities of the Martonvásár institute, but since the second reorganisation, in autumn 1950, neither Martonvásár nor any other Hungarian institution has been charged with this duty. Admittedly, in 1953, when they were reorganised into regional institutes, the plant breeding stations themselves ceased to exist. It is worth noting that in the meantime the regional institutes have been repeatedly reorganised and some have been put under the authority of the agricultural universities, while the fate of the institute which is the legal successor of the Iregszemcse plant breeding station is now under discussion, the options being to close it or place it under an enterprise or agricultural university.

Below, an answer will be sought to two questions: 1. In retrospect, can the changes outlined above, and the liquidation of the plant breeding stations, be regarded as positive? 2. Was a certain academician and professor of agronomy right when, a few years ago, he criticised the Martonvásár Agricultural Research Institute of the Hungarian Academy of Sciences for not fulfilling what was basically the Magyaróvár function of setting an example for Hungarian plant breeding?

I.

First, let us take a look at the Magyaróvár institute and the plant breeding stations. Like its foreign counterparts, the Royal Hungarian Plant Breeding Institute, founded in 1909, was faced with three main tasks: 1. The professional supervision of Hungarian plant breeding and the promotion and direction of the practical side of breeding, i.e. the propagation and popularisation of new plant varieties. 2. The actual breeding of certain crops, according to need, on its own trial grounds, using its own resources; the introduction of suitable foreign plant varieties, and the study and perfection of the agricultural utilisation of wild plant species. 3. The development of plant breeding knowledge through theoretical and methodological research, combined with literary activities and professional lectures and courses aimed at spreading plant breeding knowledge and new experiences. As the headquarters of this branch of science, the work of the institute included the scientific and methodological supervision of the whole of Hungarian plant breeding, on-site checks on the handling of breeding stock, the evaluation (yield potential, quality and yield stability) and state certification of promising lines, the up-to-date propagation of state certified plant varieties, the development of seed production, and the overseeing of the essential facilities (seed cleaning equipment, seed stores, etc.) necessary for successful plant breeding and seed production.

With the cooperation of the Magyaróvár institute, plant breeding stations of high repute developed from small beginnings in a relatively short time (10—20 years) as private enterprises on the then large estates. Compared to the period before the first world war, plant breeding stopped being a hobby and became a profession and a business; in other words, empiricism was transformed into science. From the beginning of the twenties, under the directorship of first Grabner and later Villax, Magyaróvár considered one of its chief functions to be the collection of initial stock from all over the world, the systematic testing of the collection, the popularisation of hybridisation, progeny testing and precise field experimentation in the plant breeding stations and the introduction of modern variety testing. Later, Magyaróvár expanded operations to cover the basic plant breeding sciences, genetics and plant physiology. Between the two world wars, when Hungarian plant breeding reached its height, outstanding plant breeders (Baross, Fleischmann, Székács, Legány, Sedlmayr, Horn and others) working at excellent breeding stations (Bánkút, Kompolt, Lovászpatona, Horpács, Iregszemcse, etc.) put their creative powers to the service of Hungarian agriculture and spread the fame of Hungarian science far beyond the borders of Hungary (e.g. the first prize won by the Bánkúti wheats at the world exhibition of wheat in Regina, Canada, in 1933). But Magyaróvár also played a part in the most significant breeding achievements of the best breeders (e.g. the seed samples of the Canadian variety Marquis, which formed the basis, totally or in part, of the Bánkúti wheats, reached Baross via Magyaróvár). And practically every recognised Hungarian plant breeder of our time studied plant breeding at a course in the Magyaróvár institute.

Meanwhile, the requirements to be met by new plant varieties became more stringent. In addition to yield potential, other characters such as quality and yield stability, particularly various types of resistance (to climatic conditions, lodging, disease, etc.), received more and more emphasis. But it was impossible for the breeder to be an expert on so many subjects and the numerous analyses could not be carried out without laboratories equipped with the necessary specialists and instruments. The practice in the agriculturally developed countries, whereby farmers were given scientifically based instructions on the optimum production technology when they bought improved seed, began to gain ground in Hungary, thus necessitating the setting up of agrotechnical experiments. So modern plant breeding developed into teamwork, which meant that in Hungary after the second world war there was a call for complex plant breeding stations equipped with the staff and facilities required for up-to-date plant breeding: a team led by a breeder and including a geneticist or physiologist, experts on resistance and quality testing, and an agrotechnician + nurseries and the necessary instruments and laboratories.

However, from the mid-fifties onwards the attempt at creating complex plant breeding stations resulted in the setting up of regional institutes and/or specialised institutes, and this, as can still be perceived today, had a number of negative consequences, the most serious of which were:

a) With one or two exceptions, the management of the institutes which took the place of the plant breeding stations fell into the hands of scientists other than breeders, which led to a decrease in the significance and respect attached to plant breeding. In fact, Bánkút, which had the finest tradition and perhaps the best soil and climatic conditions of all the excellent plant breeding stations, simply ceased to exist, i.e. it was not maintained even as a regional institute.

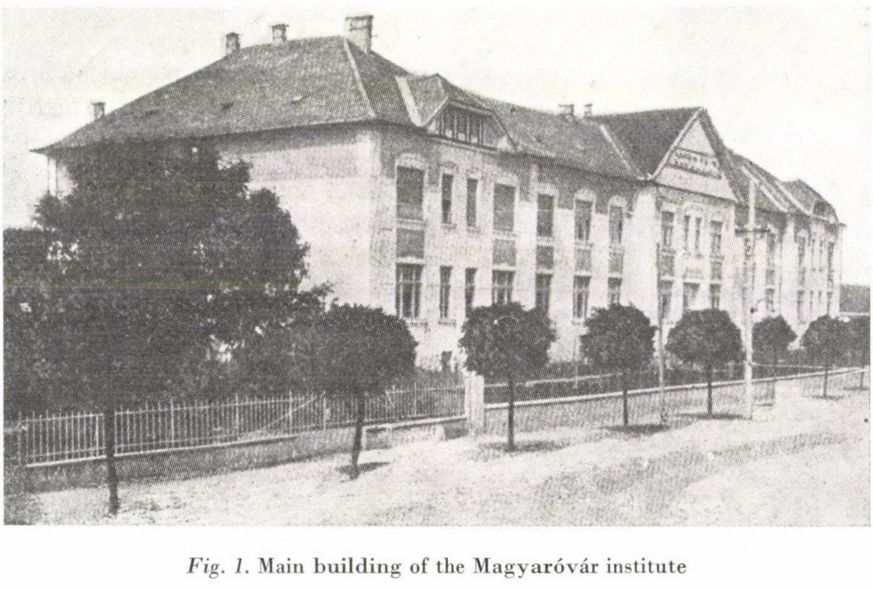


Fig. 1. Main building of the Magyaróvár institute

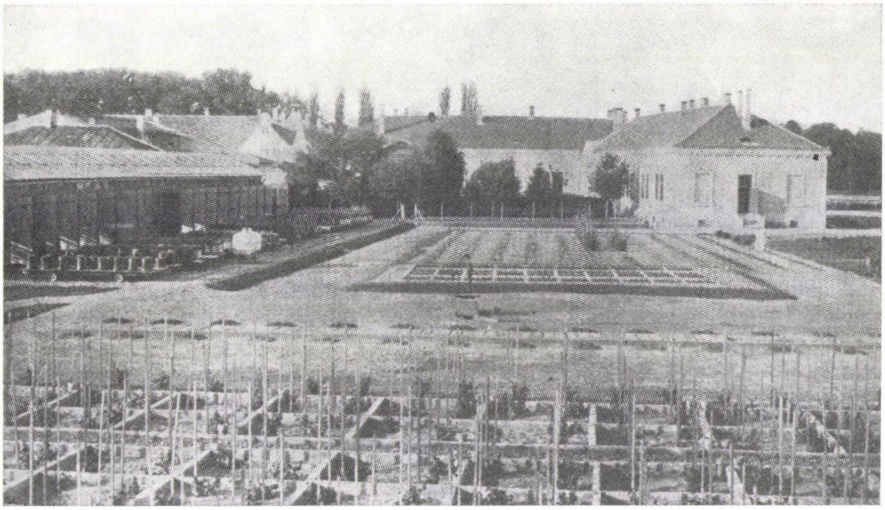


Fig. 2. Nursery in the grounds of the Magyaróvár institute

b) When the fairly simply administrated plant breeding stations (consisting in the early fifties of an experimental farm with a plant breeder as head of research) were reorganised into institutes, the superfluity of red tape, a problem which was becoming characteristic of the whole of society, made many things more important to the research institutes than research itself, so the chances of developing plant breeding and bringing it to fruition became even poorer, as it was overshadowed by other disciplines which were part of the institute profile but were not directly of service to plant breeding. It is no wonder that under such circumstances the complex conditions needed to turn plant breeding into teamwork were only partially fulfilled.

Consequently, in retrospect the liquidation of the plant breeding stations can be judged to have had a negative effect.

II.

The answer to the second question, dealing with the extent to which Martonvásár has taken over the role that Magyaróvár played in setting an example for Hungarian plant breeding, can be summarised as follows.

When the Martonvásár institute was established the milling and baking quality testing laboratory of the Magyaróvár institute was transferred to Martonvásár in its entirety and for a time functioned as a central plant breeding facility in examining wheat samples sent in from the plant breeding stations. In a similar manner, in the first few years after its establishment, Martonvásár carried out a large number of chemical quality tests for the plant breeding stations and still continues to develop methods for testing the quality of new varieties.

The evolution genetics research on the Triticinae subtribus begun in the early fifties, and the remote hybridisation on which it was based, can be regarded as a continuation of the Magyaróvár tradition, since directly or indirectly this theoretical and methodological research was of service to plant breeding, though since Rajháthy emigrated to Canada in 1956 it seems to have suffered from a poverty of ideas.

It is barely fifteen years since organ fusion, which can be considered as the precursor of the promising technique of cell fusion, was regarded with disfavour. In fact, the research itself, namely the elaboration of a method by which part of the fruit of the egg-plant was transplanted at Martonvásár in the mid-sixties, was classified as heretic. When part of a polyspermous fruit is transplanted, the graft will take, the seeds contained in the graft will ripen and are capable of germination if sown, and in appropriate transplantation combinations the progeny of seeds growing in the transplanted components will exhibit various changes. The most easily recognisable aspect of these changes is manifest in the colour and shape of the fruit. The changes in the colour of the fruit show a transition between those of the common violet and the white egg-plants. In the first generation of plants grown from seed the degree of change is quite significant, around 20%. When seeds from the first generation are sown the progeny show still greater hereditary diversity, i.e. segregation.

Research on flowering biology, which has been underway at Martonvásár since 1957, serves a similar purpose. Flowering biology is one of the basic sciences of plant breeding and seed production, but a knowledge of flowering processes is also of fundamental importance in plant genetics. Studies and observations on the degree of open and closed flowering; the viability of the stigma and the pollen grains, and the effect of their developmental stage on fertilisation; the role played in seed setting by the date of flowering in mother plants and pollinators, nicking in the flowering times and the amount of pollen; the course of flowering and of the opening of individual flowers; and the mechanisms by which flowers open two or three times, in experiments on fertile wheat and on the male sterile analogue, led to the basic research at Martonvásár on hybrid wheat and pollen storage.

As far as the prospects of basic research on hybrid wheat are concerned, the grain yield of certain male sterile × restorer F_1 hybrids exceeds that of the best standards by 20—25%, averaged over a number of years in comparative microplot trials, but the plant height also exceeds that of Bezostaya 1 by 10—20%. For F_1 hybrids produced by crossing the male sterile analogue of the dwarf variety Krasnodar 1 with the best Martonvásár restorers the plant height is satisfactory, but not the yield potential. Progress in this respect is expected from the F_1 hybrids of restorer and male sterile analogues of new dwarf and semi-dwarf lines bred at Martonvásár, which have considerably higher yielding ability than dwarf Krasnodar 1.

Studies on the storability of maize, rye and wheat pollen in liquid nitrogen at −196°C and in a deep-freeze at −76°C have been in progress at Martonvásár since the mid-seventies. Since pollen can only be stored at these temperatures if the moisture content is sufficiently low, various drying methods must be elaborated and tested in order to determine under what conditions it is possible to reduce the originally high water content of cereal pollen without destroying the viability and fertilisation ability. Now that the fundamental problems involved in storing maize and rye pollen have been solved the emphasis is on finding out how to store wheat pollen and on complementing the research with biochemical and ultrastructural analyses.

With the introduction of hybrid maize breeding by crossing inbred lines and the production of Mv DC 5 and Mv DC 1, which won immediate acclaim and hallmarked his work at Martonvásár, Endre Pap, who was transferred to Martonvásár from Mindszentpuszta in a roundabout way, opened a new era in Hungarian maize breeding. Thanks to the yield surplus given by the first hybrids, to the seed production system developed on the basis of experiences gained in America in 1955/56 and to the seed plant at the institute's experimental farm, which is equipped with American machinery, the use of hybrid maize seed became general in Hun-

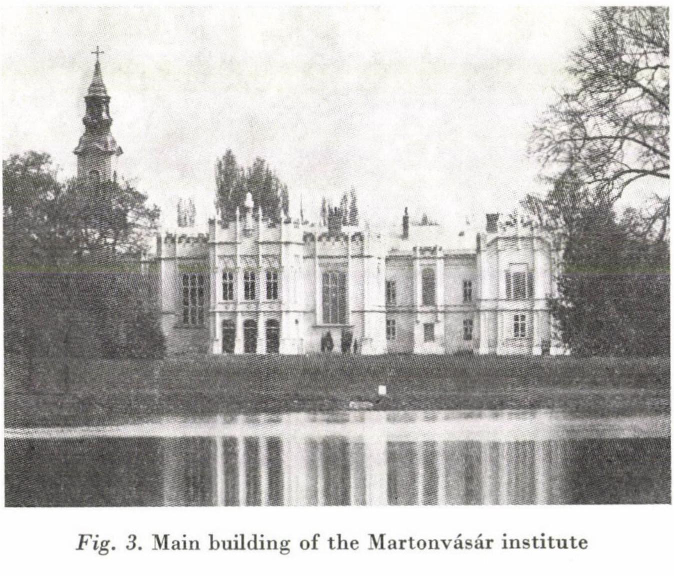


Fig. 3. Main building of the Martonvásár institute

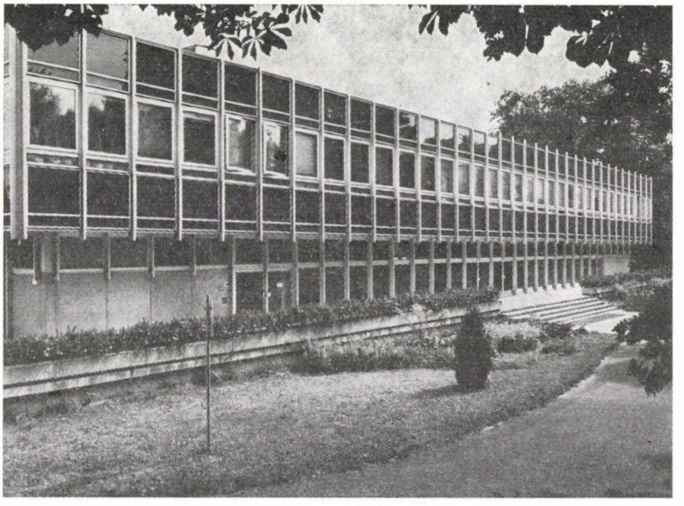


Fig. 4. The Martonvásár phytotron

gary within seven years, and led to the tripling of Hungarian maize yield averages within the historically brief period of a quarter of a century. Also, in comparison with the open-pollinated varieties, it brought the national economy a surplus profit to the order of thousands of millions of forints a year.

Numerous young maize breeders grew up under Endre Pap's guidance at Martonvásár and, after 1956, in Kelvedon, England, and these now form the backbone of the Hungarian maize breeding staff. The Martonvásár maize hybrids bred by the young researchers who stepped into his shoes maintained their leading role in Hungary for about another fifteen years and in the meantime up-to-date cultural practices, with which the full genetic yield potential of the Martonvásár hybrids could be achieved on the best maize fields of the best farms, were elaborated and made common knowledge.

Among the state registered Martonvásár hybrids special mention should be made of the sweet corn, which can be processed in numerous ways and is much in demand on the world market. But interest is also likely to be shown in a recently registered Martonvásár waxy maize, the starch content of which is almost exclusively amylopectin. This is important because the amylopectin required for the domestic food, textile, paper and drugs industries is at present imported from abroad. In addition, maize with a high amylopectin content is more efficiently utilised by the digestive system of young animals than common maize. Before waxy maize could be successfully selected, however, quality testing methods had to be developed.

Examinations on the improvement of maize protein content have been carried out in the institute for a number of years by a team of physiologists, breeders and agrotechnicians, and have led most importantly to the determination of the protein yield and protein quality of hybrids which are marketed all over the world, and to a realistic evaluation of the correlations between the yield potential, protein yield and protein quality of the hybrids.

Physiological research on the Fusarium resistance of maize has provided new data on the protective role of sugars and on the vegetal phenol derivatives as resistance factors.

The average temperature in Hungary during the vegetation period is 17—18°C, considerably less than the 24—26°C which is optimum for maize growth, while at the beginning and end of development the weather is even cooler than average. In extremely heat-deficient years the seed germinates poorly, the plant stand is patchy, ripening is delayed and there is a considerable reduction in yield. The yield stability determined in long-term experiments for types, lines and their hybrids, selected, partly in the phytotron, for resistance to sub-optimal temperatures, was significantly better than that of the standard hybrids. Thus, maize resistance to heat deficiency can be improved and deserves as much attention under Hungarian conditions as the most important yield-promoting factors (fertilisation, irrigation, heterosis).

The gradual decline of Martonvásár hybrid maize over the last decade only coincided chronologically, i.e. without any causal relationship, with the high degree of genetic vulnerability experienced in maize hybrids based on inbred lines, a factor which has encouraged maize breeders and geneticists all over the world to use new initial stock in new ways; according to Wellhausen this could mark the end of the pre-history of maize breeding and the beginning of the history proper.

Simultaneously with the gradual exchange of Martonvásár hybrid maize for other, mainly foreign hybrids, an exchange in the opposite direction is taking place in Hungarian wheat production, where foreign varieties are being ousted by domestic varieties, mostly from Martonvásár. These varieties have their origin in the winter wheat breeding which started from scratch at Martonvásár in the late spring of 1956, when the first crosses were made.

At the end of the fifties, since no Hungarian-bred intensive wheat varieties responsive to a high level of fertilisation and suitable for combine harvesting were as yet available, the introduction of intensive foreign varieties, including Bezostaya, was urged as a temporary solution, until satisfactory varieties could be produced by Hungarian wheat breeders. By the end of the sixties Bezostaya was sown on more than three-quarters of the country's wheat growing area and made a fundamental contribution, when used in combination with the recommended cultural practices, to the doubling of Hungarian wheat yields by the beginning of the seventies. At the same time the introduction of Bezostaya gave Hungarian breeders a breathing space for the development of intensive varieties, which began to appear at the end of the sixties.

The Martonvásár winter wheat varieties which have been state registered from the early seventies onwards and which are characterised mainly by their quality and yield stability, are now grown on approximately one third of the national wheat growing area. And each year the Martonvásár maize hybrids and barley varieties are joined by more and better Martonvásár wheat varieties, which are marketed together with specific agrotechnical recommendations elaborated by the researchers.

Wheat research is now aimed at breeding a short-strawed (70—80 cm) type of wheat with excellent milling and baking quality, resistant to climate and diseases, and capable of giving a stable grain yield of 8—10 tons/ha under farm conditions. To set this aim for wheat breeding and hope to achieve it within the foreseeable future is only realistic with the help of the Martonvásár phytotron, which has been operating since the end of 1972 and which enables the breeding time to be reduced, the breeding stock, particularly the number of new combinations available for selection, to be increased many times, and the frost resistance of the varieties and lines to be objectively tested. But first of all it was necessary to learn how to use the phytotron and to adjust wheat breeding methods for this purpose by elaborating a new wheat breeding strategy combining field and phytotron techniques, which in itself necessitated, and still does to some extent, intensive experimentation (to raise 2×2 winter wheat generations a year, to break the dormancy of the germ, to achieve nicking in the flowering times of varieties with different vegetation periods, to test the efficiency of crossing methods, to determine the earliest possible harvest date, etc.).

However, it is not only for Martonvásár wheat breeders that the Martonvásár phytotron, which is put to the service of plant breeding and of its most important basic science, genetics, has opened up new, as yet undreamed-of prospects. The phytotron method elaborated at Martonvásár for testing the frost resistance of winter wheat (cereals), which can be carried out at fortnightly intervals throughout the year, is available not only to the Martonvásár breeders, but also, as a Magyaróvár type of service, to all Hungarian plant breeders and other interested parties. At the request of the Warsaw agricultural administration a FAO consultation on the frost resistance test was held in Poland in November 1979. The following is a by no means complete list of the subjects of experiments carried out in the Martonvásár phytotron for non-Martonvásár Hungarian and foreign researchers (with the place of work in brackets for the foreigners): raising of rye plants for Claviceps inoculation; maize cold test; barley hybridisation; flowering biology of beans; frost resistance of wheats; selection of Achillea and camomile; stem formation of kohlrabi; forcing of vine grafts; frost resistance of camomile types; germination of sugar beet and maize with gibberellic acid; frost resistance of flowering fruit trees; phytotoxicity of maize types; testing of herbicide antidotes; frost resistance of vines; production of plant stock for raising haploids from wheat anthers; vernalisation requirement of winter wheats in the plant state (Odessa); heat and light response of winter and spring wheats (Paulinenaue); fertility test on wheat restorers (Hadmersleben); uniformity of maize seed (Osijek); variation amplitude of the leaf number in wheat plants (Bari); cold tolerance of maize (Egyptian guest researcher); drought resistance of maize (Indian post-graduate). Nor should it be forgotten that regular assistance is given to Hungarian and foreign research institutions with phytotrons or phytotronic chambers and/or cabinets in raising and testing plants and in installing and repairing the equipment.

The autumnisation programme carried out at Martonvásár, which is regarded as heretical by official genetics, and the research on aneuploid genetics which has developed from the monosomic analysis carried out over the last 15 years or so as part of this programme, are both partially concerned with plant breeding and in recent years have represented two chapters in the programmed production of agronomic characters.

In early stages of development spring wheats do not require a temperature near the freezing point and shortening daylength if they are to flower. However, if spring wheat is sown at successive dates in the autumn for consecutive generations the genetic constitution can be changed to such an extent that exposure to a temperature near the freezing point and shortening daylength become necessary if flowering is to be induced; in other words, spring wheat can be autumnised. Both conventional and aneuploid genetic analyses and complex physiological and biochemical tests (vernalisation, photoperiod, winter hardiness, chlorophyll content, assimilation temperature, accumulation of organic matter, intensity of growth and cell division, enzyme activity) have proved that the original stock used in the autumnisation experiments at Martonvásár was pure spring wheat, while the autumnised variants were pure winter wheat.

Autumnisation as an adequate genetic change induced by a change in the environment can only be exactly studied, however, under reproducible experimental conditions in a phytotron. This was the fundamental motivation for the establishment of the Martonvásár phytotron and consequently for the elaboration and continual development of a complete plant raising methodology which simulates nature as far as is possible and necessary, making it unique in the history of phytotrons, and which has been of service to the whole of phytotronic research.

So far the repeated use of numerous phytotron climatic programmes, compiled from an analysis of the climatic conditions during the autumnisation of classical and Mexican spring wheats in the field, has led, reproducibly, to a maximum of two weeks' delay in the heading of the spring wheats examined. This is quite literally a half-success, since under Hungarian conditions autumnisation can be recorded if there is a delay in heading of approximately one month. The continual perfection of the climatic programmes and the plant raising techniques will no doubt lead to complete success, i.e. to the achievement of reproducible autumnisation.

The difficulties which have arisen in the course of autumnisation in the phytotron have stimulated attempts to develop the theoretical side of phytotronics. One result of this is the invention of "inhomogeneous optimation", a 50% Martonvásár invention which was patented in the United States of America in 1978 and in Canada in 1979. Up till now reproducibility has been based on the homogeneity of the raising conditions. The use of the invention means that the research aim can be achieved more simply and rapidly, with a much smaller experimental area, less material and a lower number of individuals, and even types of optimation which have previously seemed insoluble are now possible.

The institute's maize agrotechnicians are the co-authors of another Martonvásár invention, patented and applied since 1978, which deals with a method for the production of certain oil-based herbicides and has already brought the institute a fair amount of income.

The biochemical research on vernalisation and frost resistance, which has been independent of the autumnisation genetics research since 1973, has shown that there is a close correlation between the frost resistance of winter wheats and the intensity of photosynthesis in the plants at low temperature, the translocation system, the growth responses and the ability to synthesise enzymes and nucleic acids. It should be possible to develop the test elaborated on the basis of this research into a method suitable for the evaluation of the frost resistance dynamics of different varieties and the estimation of local frost resistance.

Aneuploid genetic research began with the production of monosomic series for the winter wheat varieties Mironovskaya 808 and Rannyaya 12, which have many contrasting characters; it continued with the utilisation of these monosomic lines and the ditelo series of Chinese Spring to produce reciprocal substitutions between different varieties, first of all in the 5th and 2nd homoeologous chromosome groups, responsible for autumn-spring character and straw length, respectively; and was finally extended to include the inheritance of frost resistance.

The main aim of barley breeding, which was begun by Béla Friedrich immediately after the establishment of the institute using breeding stock brought from Diószeg, has been not only to raise the yield potential, but also to improve the standability and disease resistance. At present Martonvásár spring malting barleys and winter fodder barleys are sown on two-fifths of the Hungarian barley growing area.

The propagation, processing and marketing of the seed of plant varieties and hybrids bred at the institute, together with farm-scale experimentation, is undertaken by the institute's experimental farm. The seed propagation and farm production of new varieties and hybrids are both promoted by the extension service run by the institute and experimental farm. The wide-spread national and international cooperation which has developed with respect to seed production and marketing has considerably enhanced the efficiency with which plant breeding results are put into practice.

Perhaps the most important of the farm experiments carried out by the institute farm is that which deals with the utilisation of the whole maize plant, i.e. not only the grain yield, but also the stalks and cobs. The experimental feeding of ruminants with maize stalks and cobs enriched with NPN, mineral salts and vitamins, begun a few years ago as an adaptation of the technique developed on the Garst Farm in America, holds out the prospect of increasing the amount of complete ruminant fodder which can be gained through maize production by a half or two-thirds. The development of a natural husbandry system based on this method may well be the only way to make Hungarian cattle production profitable.

The international scientific conferences organised at Martonvásár, either alone or in cooperation with international organisations, are of excellent service to both the research and the foreign relations of the institute; the most recent of these, on agricultural production and human nutrition, was held in June 1978 at the instigation of the United Nations University and under the aegis of the Royal Swedish Academy of Sciences and the Hungarian Academy of Sciences, with the participation of invited specialists from the five Nordic countries, the eight planned economy countries of Central and Eastern Europe and five specialist agencies of the United Nations. A similar role is played by the journal Acta Agronomica Academiae Scientiarum Hungaricae, which has been edited at Martonvásár since 1965.

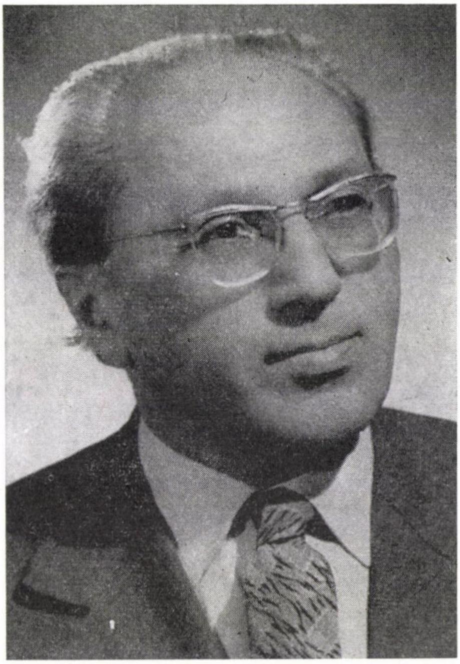
Martonvásár not only cooperates in international research but also takes an active part in the international organisation of research. For instance, for the last 5 years, Martonvásár has been the coordination centre for the FAO maize research network and for the subnetwork on the utilisation of the whole maize plant.

*

This will perhaps give some idea of the extent to which Martonvásár, during the first 30 years of its existence has lived up to or fallen short of expectations that it should take over Magyaróvár's function in setting a professional example for Hungarian plant breeding. But having been director of the Martonvásár institute for the last quarter of a century I am hardly qualified to pass judgment in this matter. In conclusion I should just like to make a few comments on the arguments which arise from time to time in connection with the development in Hungary of plant genetics, the most important basic science of plant breeding.

It is quite true that Hungarian plant breeding, which still occupies a distinguished place in international comparisons, will only be able to retain this high ranking if it is backed up by continual developments in plant genetics. Unfortunately, however, genetics is not afforded a great deal of respect by plant breeders. This is largely the fault of genetics itself, since wheat breeding can hardly expect any assistance from genetics as it is practised today. So far this is totally true of contemporary molecular genetics; but even mutation research has produced little more than promises for the last fifty years, and the prospects are not much better with respect to polyploidy, chromosome and gene manipulation or engineering, or even perhaps for population genetics. So considerable thought should be given to what type of genetic research should be developed in the interests of plant breeding at Martonvásár and elsewhere in Hungary.

S. Rajki



ISTVÁN NOVÁK

1906—1978

Professor István Novák died on 28th November 1978. In his person we have lost an internationally recognised expert in medicinal plant research. His hard-working life justified the heights he reached in his career.

The aim which István Novák set for his institute was to carry out phytochemical and pharmacological studies on plants used in popular medicine and to discover the structures of the medicative compounds they contained. He was primarily engaged, together with his Hungarian and foreign co-workers, in the isolation of antispasmotic substances from *Ruta graveolens*, a member of the *Rutaceae* family.

István Novák was born at Nagyenyed on 25th October 1906. His father was a pharmacist. He went to elementary and secondary school in Gyergyószentmiklós and took his final examinations at the Klauzál Gábor Grammar School, Szeged. After that he was apprentice pharmacist in Károly Barcsay's "Divine Providence" pharmacy in Szeged. In 1928 he obtained a diploma in pharmaceutics at Szeged University, and in 1930 he gained a doctor's degree from the same University. He was still a university student when he worked in the Pharmacy and Pharmaceutical Institute of the local university as a trainee and later as an assistant professor.

The talented young man attracted the attention of scientific circles with his publications. In 1931 the internationally renowned Gedeon Richter Pharmaceutical Factory (now the Chemical Works of Gedeon Richter Ltd.) offered him the post of analytical chemist in the chemical laboratory of the factory. Later he worked in the section dealing with hormone products, and then became head of the tabletting and tablet-coating plant.

The Pharmaceutical Institute of Szeged University recalled him in 1937 and he was appointed Chief Chemist of the University Pharmacy. It was during this period that he was qualified as associate professor in the subject "Production and testing of new types of medicines". He was assigned to the University Pharmacy of the Pharmaceutical Institute first at the Budapest, then at the Szeged Medical University, where he was engaged in testing medicines. He worked as an associate professor at Szeged from 13th March 1945 until 1953, when he was appointed full professor and head of department at the Institute of Pharmacognosy of the Szeged Medical University. During that year he was also Vice Dean.

Besides paying great attention to the education of his students, he established a school by instructing his immediate colleagues. As an enthusiastic pharmaceutical historian he held a special course for the students in the first term under the title "History of pharmacy".

Novák delivered scientific lectures not only at numerous conferences organized in Hungary, but also in Baku (1961), Prague (1965), Piatigorsk (1967) at the All-Union Pharmaceutical Congress; in Würtzburg (1967), Halle, Karlsruhe (1969), Munich (1970), Helsinki, Leningrad, Varna (1971), New-Delhi, Vienna, Ljubljana (1972) and Storra, USA (1975).

In the course of his rising professional career, he was elected Vice Rector of the Szeged Medical University in 1960, and was Dean of the Faculty of Pharmacy from 1961 to 1967 in the same University.

As an acknowledgement of his work, the Hungarian government honoured him with the title "Prominent pharmaceutist" in 1962, and he was awarded with the gold medal of the "Order of Labour" for his educational and research work.

His activity in the social sphere was testified by his chairmanship of popular education and peace committees, and his membership of numerous Hungarian and foreign scientific organizations.

István Novák was also president for several years of the Subcommittee on Pharmacognosy of the Pharmaceutical and Pharmacopeal Commission of the Hungarian Academy of Sciences and the Ministry of Health, and of the Medical Plant Section of the Hungarian Pharmaceutical Society.

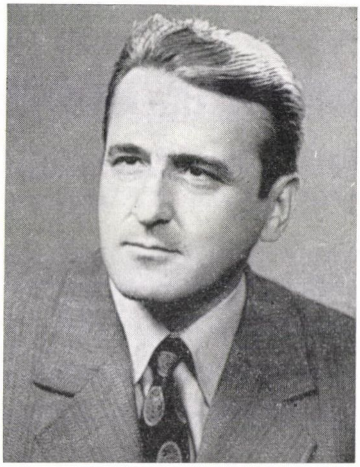
His text-book Pharmacognosy (1963), written in association with Prof. János Halmai, is up-to-date even now. He published more than a hundred and fifty scientific papers in Hungarian and foreign journals and wrote eight university textbooks, together with two educational films on ergot and paprika. His first papers dealt with the analysis of medicines. Another subject he worked on was how to keep control on pharmacies. He also tried to find a scientific solution to the practical problems facing pharmacies. Of the mediciaal plants, he focussed his attention on the heart glycosides of *Erysium diffusum* (Ehrh.), the cannabinoid contents of Hungarian and Indian hemps *(Cannabis)*, the numerous types of compounds in *Ruta graveolens*, and others. Most of his scientific works are accounts of these investigations.

This is only a brief summary of his life and career. The course of his life can be looked back on with pride, and his diligence sets us an example to follow.

L. Hegedüs

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 30 (3–4), pp. 475–479 (1981)

"AS I SEE IT . . ."



ROLE OF HOUSEHOLD PLOTS AND SUBSIDIARY FARMS IN HUNGARIAN AGRICULTURE

The Hungarian People's Republic is a small country situated in Central Europe. Most of its territory is fertile flat land, a relatively high proportion of which (some 70%) is suitable for agricultural cultivation. This proportion is at present the highest in Europe; at the same time, Hungary can be classified as a medium densely populated country. Considering, in addition, the undoubtedly favourable climatic conditions, it can be concluded that the conditions in Hungary are quite suitable for agricultural production.

This potential was exploited at a relatively early stage. In fact, Hungary was ranked as an agricultural country until recent decades and industrialization has a relatively short history. However, owing to the lack of industrial development, the retrograde social conditions and the poor supply of capital, Hungarian agriculture was still far from fulfilling its potential at the beginning of the 20th century. But after the reconstruction following World War II dramatic changes took place in the agricultural production of the country. After the land reform numerous new, small peasant farms came into existence which later formed co-operatives, while state farms were established on the large estates. Neither form was unknown in Hungary (the oldest state farm is 200 years old), but previously they were not typical and had a totally different profile. These two types of socialist large-scale farm are now characteristic of Hungarian agriculture, though a few small private farms also exist.

The advantages of large-scale farm management and the favourable ecological conditions of the country explain the great progress made by Hungarian agriculture in the course of a single generation, making it one of the first in the world as regards per capita meat production, meat exports and cereal production. Today the country produces more than three times its own bread grain requirement, and in spite of its small size some of its products form a considerable proportion of the world market.*

* In a relative and absolute sense Hungary is the biggest exporter of sausages in the world, and takes the second to fourth place among countries exporting slaughter poultry. Hungary has about 30% of the world market for red pepper.

I think these facts can rightly be considered as an achievement in which every member of the Hungarian farming community has had a share. As mentioned above, the overwhelming majority of agricultural produce is turned out by the large-scale farms. In addition, however, one and a half million families carry on agricultural production as a subsidiary activity in their own farms, which are closely connected with the large farms.

When the co-operative farms were organized the gardens around the houses, the old farm buildings and equipment belonging to the peasants and some of the livestock did not pass into collective ownership. At the same time the Co-operative Act ensured the basic right of each member of the co-operative to farm a small amount of land and obliged the co-operative to allocate so-called household plots — and recently crops too — for this purpose, in proportion to the work done in the collective farm. Since buying and selling are performed in common, the household plot forms a single unit with the collective farm, so the small farms of the 750 thousand co-operative members belong in this category. What livestock are kept and what crops are grown are determined by the co-operative through decisions made at the general meeting.

The term subsidiary farm covers the small-scale farming activities of industrial and commercial workers, or of people who are no longer members of the co-operative, and who are either employed in other fields or have retired. There are nearly 800 thousand of these small farms.

Half the total population of Hungary, some 5 million people, spend their spare time working on household plots and subsidiary farms. The value of the farm buildings, equipment and tools in their possession amounts to several thousand million forints, which is an integral part of Hungary's national wealth. An area of about 1 million hectares, most of which is unsuitable for large-scale production owing to its size or situation, is cultivated in this way. The exploitation of these possibilities is in the national interest, because they represent a useful complementation of the production of the large-scale farms, and in many cases make it unnecessary for them to deal with certain branches of agriculture. Last year the gross production value of household plots and subsidiary farms exceeded 61 thousand million forints, which is about one-third of the agricultural production of Hungary.

More than one-fifth of the agricultural fixed assets in Hungary is in the possession of household plot and subsidiary farm owners. This includes accommodation for 1.3 million cattle and horses and nearly 5.5 million pigs, and some 4 million square metres of poultry houses; if these animals had to be housed in the large-scale farms, it would tie up the investment resources of this whole branch of agriculture for at least five years. Still more important than the economic interest is the social policy achievement, the way those concerned, producers and consumers alike, appreciate this economic policy.

As far as crop production is concerned, apart from the traditional wine production and fruit growing, the household plots and subsidiary farms produce more than 60 different crops for which the domestic demand is relatively low, but where a shortage would cause a serious disturbance in the population's food supply. The small farms occupy a special place in crop production, making up 90% of the market gardens, 45% of the vineyards and 30% of the orchards. Since these crops have a high manual labour requirement and are almost impossible to mechanize, and due to the limited capacity of the national economy, they cannot be taken over by the large-scale farms within the foreseeable future.

These small farms also account for three-quarters of the poultry, more than half of the pigs and 26% of the country's cattle stock. Their feed includes by-products that could only be made available in large-scale farms at the expense of other crops. If this livestock were transferred to or bought by the state and co-operative farms, with a simultaneous increase in the fodder requirement, it would tie up considerable financial resources and impede the realization of other necessary investments by the large farms.

The importance and social usefulness of the household plots and subsidiary farms is determined primarily by their role in improving the food supply. This contribution is indispensable in satisfying food requirements and increasing the stock of export goods. Approximately half the produce of the small farms is consumed by the families involved, while the other half is taken to market or bought up by trading organizations, and thus improves the food supply. The household plots and subsidiary farms play a particularly important role in vegetable and fruit growing and in cattle, pig, poultry and rabbit rearing.

It is obvious that the 10% of arable land managed as household plots and subsidiary farms would not in itself render this level of farming possible. This type of farm does not exist in a vacuum, but co-exists with the socialist large farms, which provide massive support. It can thus be justly claimed that one of the most important features of the household plots and subsidiary farms is the great range of assistance offered by the co-operative farms and by other farming and trading organizations, including help with buying and selling, technological advice, and the loan of transport and equipment. This work is the responsibility of 2900 experts in the large-scale farms, for 1560 of whom it is a full-time occupation. Without their active support the conditions necessary for the small farms would probably cease to exist. These large organizations provide breeding material, fodder and servicing, and market the goods on a contractual basis. It is in the mutual interest of the large farms and the household plots and subsidiary farms to develop and deepen this co-operation. It is characteristic that 98% of the slaughter pigs and about 80% of the beef cattle produced by small farmers are sold through the large-scale farms or consumer co-operatives. The value of pigs sold for pork by small farmers through the large-scale farms rose from 3 thousand million Ft in 1976 to more than 8 thousand million Ft in 1979. If a predetermined volume is delivered, the food industry purchasing the animals pays the large-scale farms a so-called "bulk bonus", thus acknowledging the advantage of buying up a large amount in one lot. But since the large-scale farm obtained part of the animal stock from the household plots and subsidiary farms, the co-operative farm shares the bonus with the small farmers.

The close co-operation between the collective farms and the household plots is promoted by household plot committees formed in the co-operatives. The intensive development recently observed in the number of livestock kept by people possessing little or no land has been made possible due to the high yields produced by the co-operative and state farms. The increasing co-operation between certain co-operative farms and small producers can be illustrated by the satisfactory provision of roughage, fodder and straw for the cattle and rabbits owned by the small farmers. In addition, the small farmers are supplied by 5400 feed stores throughout the country, the smooth operation of which is one of the preconditions and main guarantees of small scale production.

Experience shows that mutual interest is particularly strong when animals owned by large farms are reared by small farmers. In this case the large farm guarantees the feed supply, the veterinary service, and possibly helps to mechanize the farm buildings; in other words, it provides all the conditions necessary for livestock farming except the manual labour and the farm buildings. In return for the work laid down in the contract and for the use of the small farmer's equipment the large farm makes a cash payment, or, for members of the co-operative, gives credit for a certain number of working days, or compensates the small farmer in other, very inventive, ways.

The co-operation between large-scale farms and small farmers is embodied in the form of a contract which guarantees production security for the small farmer. Ninety per cent of small farms producing a larger quantity of goods sign a contract valid for several years. Specialization, involving a reduction in the range of products, with a simultaneous increase, in excess of personal needs, in the volume of those products retained, is becoming more and more characteristic of the household plots and subsidiary farms. This transformation makes it essential to plan production, increasingly adjusting it to the actual requirements of the population. In order to ensure uniform quality the large farms undertake to produce some 50 thousand young sows in farrow a year to be handed over to the small farmers within the framework of a preferential rearing campaign and direct sales. In addition, more than 100 thousand young porkers, 15 million baby chicks and 32—35 thousand breeder rabbits are sold each year to the household plots and subsidiary farms.

With the guidance of the state and co-operative farms the small farms have successfully adapted large-scale methods. For example, pigs and poultry are kept under the most up-to-date conditions by small farmers in the "15th March" Co-operative Farm at Hernád; pigs and rabbits in the "Petőfi" Co-operative Farm at Dunavarsány; and rabbits and pigeons in the "Red October" Co-operative Farm at Ócsa.

Small farmers are also backed up by the large farms in many ways when starting up production. At Hernád, for example, those undertaking to rear poultry may be given a credit of up to 80 thousand forints.* The co-operative farm supplies modern technology, coops, automatic fountains, feed and regular professional advice. This leads to advantageous uniformity, with the result that the small farmers are able to produce goods which meet the strict export requirements. The ambition driving the small farmers and their faith in the agrarian policy are demonstrated by the fact that in the last four years a total of 4.8 thousand million loans have been granted to small farmers by national and local savings-banks.

Within the framework of the farm contracts, for example, the large-scale farms buy up 60 thousand tons of grapes, 160—200 thousand hl grape juice and 500—600 thousand hl wine from small producers. The services provided by the organizing farms, which are constantly being extended and at present have an annual value of 1.2—1.3 thousand million forints, guarantee yield reliability. The close co-operation with the household plots and subsidiary farms is indicated by the large-scale production of the seeds and seedlings required for vegetable growing, the widening range of propagation material available for the plantations and the up-to-date, planned planting of vines and fruit-trees in the household plots.

Small farmers in Hungary are organized in nearly 2700 specialized agricultural groups. Each specialized group consists of small farmers who produce identical or similar products. The most frequent specialized groups deal with horticulture, vine and fruit growing, pig fattening, small animal breeding and apiculture. Particularly among the small animal breeding groups, there are a considerable number of special groups engaged exclusively in rearing a single kind of animal, e.g. rabbits, geese or pigeons.

The general purpose of the specialized group is to ensure production and processing in one or more branches of agriculture, to provide the necessary services for its members and to arrange collective buying and selling. Production is carried on individually, in the members' own farms. It is also possible, however, to carry out either production, e.g. seedling raising, operation of a chicken hatcher, etc., or processing or marketing in common. Most of the members take goods to market besides producing for household consumption, but this is not a condition of membership.

The age and occupational composition of the members in a specialized group shows an extremely wide range. The proportion of industrial workers is the highest of all, but there are also considerable numbers of farm workers from co-operative farms and of pensioners.

As a matter of fact, at times production in the household plots and subsidiary farms has declined in some places. This has been due in the main to the underrating of household plot production, incorrect methods, occasional local abuses, badly planned attempts at urban-

* For comparison: this is about twenty times the current average monthly wage in Hungary.

ization, a reduction in the financial incentive and a lack of organization in buying up the produce. It is not unusual for people to think that small-scale production is an easy way to get rich, that it causes inequality, or that it withdraws labour from the work done in the collective farm. Large-scale farm managers who fail to see where their interest lies, and a bad system of taxation have often caused considerable damage to household plot and subsidiary farming.

These difficulties have mostly been overcome now, but household plot production calls for regular and intensive attention. During the last five years the state and social organs involved have determined what needs to be done and gave gradually established the conditions required for the development of small-scale production in most fields. The modernization of legal and economic measures concerning every important sphere of small-scale production has also been attended to. The regulation of production, marketing and taxation, and questions of labour and social policy in connection with household plots and subsidiary farms have been brought up to date. Following measures taken by the state organs, principles have been elaborated and suggestions made by the National Co-operative Council, the National Council of General Consumers' Co-operatives and other organizations with a view to promoting small-scale production. A reasonable degree of modernization is constantly kept on the agenda by the bodies concerned.

The agricultural authorities have repeatedly protested against phenomena which interfere with the interests of producers and the national economy alike. They have consistently maintained that the production from household plots and subsidiary farms, particularly in the pig, poultry, small animal and horticultural branches, will remain important both for home consumption and on the market for a long time to come.

At the same time, the question of household plot production, which has yielded considerable results in Hungary, cannot be confined to government measures. The fact is, that household plot and subsidiary farming is a concept connected with a certain age and occupational group of the population. The archetype of the household plot farmer is a man who is no longer young, who lives in a village, and whose job in the cooperative farm involves the same type of manual work. Very often this work is done by old age pensioners with no-one to support them, either in order to make life easier for themselves, or more frequently to help their children and grandchildren to fulfil their desires. And they often do this work simply because they find it natural to do so, because they like working and cannot live without being meaningfully occupied. It is in the common interest to supply this stratum of society with good quality equipment at an acceptable price, rather than allow various firms to palm them off with every kind of luxury tools; to give them the respect and remuneration their work, done with no little sacrifice, deserves; and finally, to ensure that all the firms which come into contact with the household plots as suppliers or buyers do their work with great competence and flexibility.

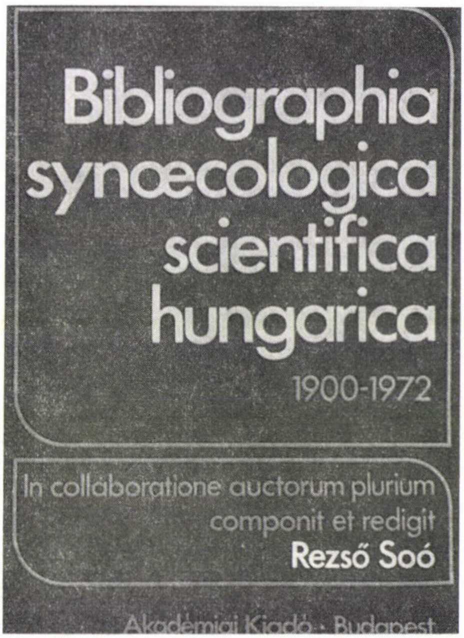
This is the only way to ensure that this variegated type of farm, backed up by the hard creative work of a wide stratum of society, will continue to make a valuable contribution to the food production of Hungary for a long time to come.

P. Romány
Minister of Agriculture and Food
of the Hungarian People's Republic

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 30 (3–4), pp. 481–492 (1981)

RECENSIONES

R. Soó et al.: Bibliographia synoecologica scientifica hungarica 1900–1972. Akadémiai Kiadó, Budapest, 1978.



The Biological Section of the Hungarian Academy of Sciences satisfied a long felt need, when, on the occasion of the 150th anniversary of academic publishing, it edited a detailed bibliography of the Hungarian synoecological literature of the 20th century. The responsibility for compiling this work, which required close familiarity with the literature, outstanding professional knowledge, great editorial ability and considerable experience, was entrusted to Rezső Soó academician. With the contribution of eleven other collaborators he has produced a 500-page volume which presents the relevant Hungarian literature of nearly three-quarters of a century and which can easily be used by foreigners as well.

In the course of this work, as for any bibliography of a special field, many difficulties had to be overcome, ranging from the desire for completeness, which arises with any bibliographic work, but can never be more than approximately fulfilled, through problems encountered in separating different fields and drawing the border-line between popularizing literature, up to the large number of technical problems (e.g. citation system, translation of Hungarian titles, abbreviation of periodicals, various forms of woman author's names, reference to co-authors, reference system to avoid repetition, etc.), or even to the literary implications of changes in national frontiers following World War I.

All these problems are well known to the small number of experts who specialize in compiling bibliographies, and cannot always be solved. However, for the book in question these difficulties have more or less been overcome, due in large part to the professional knowledge of the collaborators, and, above all, to the editor's acquaintance with the subject, based on his rich library, famed throughout the country, as well as to his talent for organization and half a century's work in botanical bibliography.

To make the book more useful to foreigners, the ecological bibliography has Latin titles, as well as a subject index and chapter headings in the same language. After the introduction, written in English and German, the items are grouped within the chapters (and/or sub-chapters) in alphabetical order.

As to its content the volume is very rich: it encompasses the full synoecological literature of the period indicated. This is the first time that the Hungarian bioclimatological, soil microbiological, hydrobiological and production biological literature on environmental protection, a subject of increasing importance, has been compiled and made available. The selection does not, however, include floristic and faunistic papers of an exclusively systematic nature, human biology, or the technical, legal, etc. aspects of environmental protection. Even so, the contents of the volume are much richer than was initially expected: there is a total of 5700 items. (Although the last item is numbered 5642, many are included afterwards and marked a, b, etc., while some serial numbers have been cancelled because of overlapping.)

This vast material is grouped in 27 chapters (including a further 39 sub-chapters). Twenty of these (the general and phytocoenological chapters, the syntaxonomic and synchorological chapters, and finally the nature conservation selection) were compiled by R. Soó, either alone or with collaborators. The forestry synoecology was compiled by I. Csapody, the bioclimatology by M. Kéri, the soil microbiology by M. Kecskés, the hydrobiology by Á. Berczik, the alga synoecology by L. Hajdu and Mrs. L. Hajdu, the palynology by E. Nagy, the zoo-synoecology by B. Nagy and Mrs. B. Nagy, the zoo-synchorology by B. Nagy, and the production biology by K. Hunyadi (with the collaboration of I. Csapody, R. Soó and Gy. Tölgyesi).

The percentage of the total number of items (5700) prepared by the individual collaborators is as follows:

R. Soó	28
Á. Berczik	15
B. Nagy and Mrs. B. Nagy	15
K. Hunyadi	14
M. Kecskés	9
L. Hajdu and Mrs. L. Hajdu	6
I. Csapody	6
M. Kéri	5
E. Nagy	1
Gy. Tölgyesi	0.4

Among the branches of science treated in the bibliography the largest number of publications are found in the following chapters:

Production biology	1081 items
Hydrobiology	849 ,,
Zoo-synoecology	601 ,,
Soil microbiology	530 ,,
Synchorology	395 ,,
Alga coenology	357 ,,

It is common knowledge to anybody compiling a bibliography that works of this character, compiled by a number of co-authors, can hardly be totally free of mistakes, even when prepared with the most careful editing and printing. It is thus a great satisfaction to find that this volume contains only a few misprints, and both the arrangement of its content and its format can be said to be successful. The twenty-page author index at the end of the volume, prepared with the active participation of Alajos Jolsvay, late editor of the Publishing House of the Hungarian Academy of Sciences, is of great help to the reader.

It is only here and there that minor errors and sometimes inconsistencies are encountered (e.g. article included from 1898 or 1973), omitted or superfluous Hungarian accents (e.g. csibehúr, Timár; the consistent use of the name Árpád Dégen instead of Degen, as he himself wrote, is annoying), the capitalization of certain English headwords (e.g. 312, 422, etc.) when the others are all written in small letters, or a wrong order of figures (e.g. 3697—98; in several places on page 486), etc. In bibliographic works the polymorphism of Hungarian married women's names causes problems in many cases. For example, the bibliography has turned the pair of authors Kovácsné (Mrs. Kovács) Láng Edit—

Isépy István into three authors: L. Kovács, E. Láng and I. Isépy, and the first non-existing author is included in the author index too.

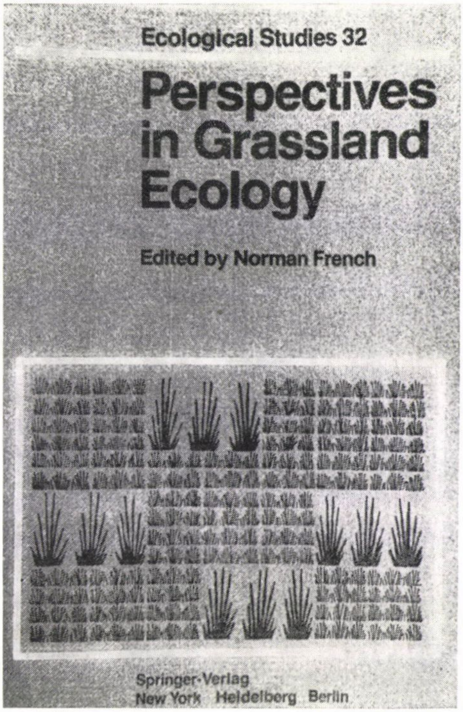
In the case of several periodicals it would be possible to consistently shorten certain longer titles when the elements of the title [e.g. Évkönyv (year-book), Intézet (institute), Mezőgazdasági (agricultural), Tudományos (scientific), etc.] have known abbreviations (Évk., Int., Mezőg., Tud., etc.) in other periodicals. It may lead to misunderstanding, particularly by foreigners, that the bibliography (like a large part of the Hungarian technical literature) uniformly uses the abbreviation "Közl." for Közlöny (bulletin) and Közlemények (publications).

It may take many years of use to find out whether anything important is missing from a bibliography. In this respect it should be mentioned that of the Hungarian bibliographies, which are, anyway, few in number (amounting to less than 50), several have been omitted: the years 1932—37 and 1944—50 (Szepesfalvi Bot. Közlem. **29**—**34;** Boros ib. **42,** Priszter ib. **46**); bibliographies on mosses (Boros 1943) and adventive plants (Priszter 1963); and the indices of the first 10 volumes of Acta Botanica (1965).

These deficiencies and the remarks made mainly on the work of compilation do not, of course, detract from the usefulness of the synoecological bibliography nor from the value of its rich contents. Through the joint work of the editor, the co-authors and the Publishing and Printing House of the Hungarian Academy of Sciences the scientific literature of Hungary has been enriched with a long-needed, useful work, the appearance of which is unequivocally welcomed.

SZ. PRISZTER

Perspectives in Grassland Ecology (ed.: Norman French). Results and Applications of the US/IBP Grassland Biome Study. Ecological Studies vol. 32, Springer Verlag, New York, Heidelberg, Berlin, 204. 60 figs. 1979.



The book summarizes the results attained in the research programme on grass ecosystems carried out by the United States within the framework of the IBP. The Grassland Biome Programme is one of the most extensive integrated research programmes carried out by the United States within the organization of the IBP, mobilizing the entire research force engaged in studies on the major grassland types in the western United States, in co-operation with scientists from Canada, Mexico and other countries.

The authors of "Perspectives in Grassland Ecology", all of whom are members of the Colorado State University, applied three methods in studying the biomass structure of grassland: 1) Comparison of North American grasslands with grassland ecosystems in other continents; 2) Comparative studies on the trophic structures of various grasslands; 3) Description and analysis of structural changes caused by artificial water and nutrient supplements.

The book discusses with exemplary conciseness nearly all aspects of grassland ecology, the possibilities of modelling, several functional implications of primary production, and the importance of aboveground and underground production and consumption in different grassland types. Finally it sums up the most important cultivation methods and treatments for grasslands. The volume contains 10 studies, which are not closely connected with each other. Each of them is complete in itself, divided into introduction, methodological section, discussion of results, summary and literary references. The studies throw light on various aspects of grassland ecology and discuss them at a very high level. They also present recent results which widen the current knowledge of the subject to a considerable extent.

In the introduction W. A. Laycock places the grasslands of the United States in 7 groups: 1) Tallgrass (true) prairies; 2) Shortgrass prairies; 3) Mixedgrass prairies; 4) Shrub steppe; 5) Annual grasslands; 6) Desert (arid) grassland; 7) High mountain grassland.

In the first chapter W. K. Lauenroth gives a comparison of the primary production of grasslands in various climatic zones. The climatic types are characterized by Walter diagrams. According to a comparison of 52 grassland types for primary production their values may range from 100 to 1400 $g \cdot m^{-2} \cdot yr^{-1}$. Within this range the grasslands of the United States, which give values of 100—500 $g \cdot m^{-2} \cdot yr^{-1}$ belong to a low production category.

J. K. Detling (Chapter 2) studied the production of the dominant grass (Bouteloua gracilis) in shortgrass prairies and the processes controlling it. He found the species in question to represent a C_4 photosynthetic type which does not reach light saturation even in full sunshine and which has an optimum temperature of about 30°C. Its primary production is controlled by the water content of the soil. Fertilization combined with irrigation may increase the gross primary production by more than 400%.

J. L. Dodd and W. K. Lauenroth (Chapter 3) examined the response of a grass ecosystem to stress in a shortgrass prairie under semiarid, temperate climatic conditions on a soil poor in nitrogen. To induce the stress they supplied mineral nitrogen, water and mineral nitrogen + water. The stress caused by a six-year treatment did not result in any change in the ecosystem in the case of nitrogen treatment; the water treatment slightly changed the functions of the ecosystem, while treatments with nitrogen + water led to a total change in its structure.

Under the title "Grassland Biomass Trophic Pyramids" (Chapter 4) N. French, R. K. Steinhorst and D. M. Swift describe studies on the seasonal dynamics of trophic pyramids in grasslands at various sites. They found fundamental differences in the trophic structure between the sites, but no important seasonal fluctuations within the sites.

In the 6th chapter J. A. Scott describes the bioenergetic model of the Arthropoda and Nematopoda groups at ecosystem level on the basis of 7 aboveground and 11 underground trophic groups.

R. G. Woodmansee studied the factors influencing the input and output of nitrogen in grasslands (Chapter 7), and found the nitrogen loss to be twice as much as the input on all the areas examined. The loss is mainly due to the evaporation of NH_3 contained in droppings.

W. J. Parton and P. G. Risser simulated management practices applied in tallgrass prairies, such as grazing, change of plant species, burning, fertilization and irrigation. They found, among other things, that spring burning every three years was useful for the material balance of the grasslands, as it repressed the annual grasses.

K. A. Radetzke and G. M. Van Dyne elaborated an experimental model for the succession of grasses on the basis of a 30-year data series (Chapter 9), and finally N. French wrote an extremely interesting study on the interaction of sub-systems in grasslands.

The book summarizes the most important eco-biological aspects of rational, up-to-date meadow and pasture management, giving a theoretical and empirical approach to the principles and controlling mechanisms of the functioning of grassland ecosystems. It is a highly important scientific source both for theoretical ecologists and for agriculturalists.

A. Borhidi

Beiträge zur tropischen Landwirtschaft und Veterinärmedizin, 2/1979. Karl-Marx-Universität Leipzig, Deutsche Demokratische Republik

Michalski, K. J.: Activity of international concerns in the agriculture of the developing countries.

The author analyses the neocolonialist strategy of the western industrial countries in the "Third World". The study encompasses the period from the end of the sixties onwards.

While the activity of international concerns was previously centred on oil, banks, mines, industry and trade, recently it has been extended to cover the development of agriculture. Since agricultural investments are mostly represented by pesticides and fertilizers, this activity is not as conspicuous as it was with earlier investments.

This form of neocolonialism is characterized by the following ambitions:

a) to direct the agriculture of backward countries,

b) to ensure the purchase of industrial products,

c) to make use of cheap labour in producing goods for export,

d) to ensure an adequate return on the capital invested.

The realization of these ambitions may provide a basis for the process in which the structures of the capitalist economy evolved in these countries merge with the international concerns.

In the United States of America the "Agribusiness Group", the major members of which are Boeing, Kodak, the Bank of America and VW, is also trying to establish a monopolistic position in agriculture. This endeavour manifests itself mainly in the delivery of machines, the financing of research work, the erection of processing units, offers of credit, and the building of industrial units for processing agricultural produce on purchased land.

In the period examined means of exercising an influence on agriculture through prices changes can also be observed. The prices of fertilizers and pesticides, for example, have increased by 200—400% since the beginning of the seventies, with the result that primarily countries with a low economic level have run into debt.

Since 1970 agriculture has been increasingly influenced by the monopolies, as agricultural research is mostly concentrated in their hands. In 1971 the CGIAR (Consultative Group of International Agriculture Research) was established in New York; more than 10 big research institutes, including CIMMYT (Mexico) and the Research Institute of Plant Genetics (Italy), belong to this organization.

The influence of the monopolies is further increased by the process of concentration in trade and transportation. The monopolization of these fields naturally includes sea-transport not only public roads. The Nestlé

Concern, for example, invested 90% of its capital abroad, and 40% of this in underdeveloped countries.

The credits offered by the World Bank do not improve the situation of the developing countries, since they are only of advantage to the richer sections of the population, and do not change the structure of agriculture. So the so-called "green revolution" indirectly promotes the development of a capitalist agriculture.

The neocolonialist policy of the international concerns also manifests itself in the purchase of land. In Brazil, for example, the area purchased covers 33—35 million ha; the Ludwig Keith Gruppe has bought 1.5 million ha in the Amazonas region, and the concern 140 thousand ha in Brazil.

The international concerns are endeavouring to colonize agriculture in Africa, Latin-America and Asia in a similar manner.

Glanze, P.: Influence of the yield of small areas on the manner and time of discharging combines.

The author uses mathematical methods to analyse ways of utilizing combines on small production areas. Comparative examinations are made primarily from the point of view of what the optimum conditions are under which grain can be transferred from the combine to the appropriate transportation facilities in the shortest possible time.

In this paper correlations between the size of the crop and the frequency of discharge, as well as the interactions between yield and discharging methods are studied. The latter includes calculations concerning the efficiency of discharging en route, while standing or at reduced speed.

The author establishes that on small plots combines cannot be used economically. However, the use of the machine is the most profitable when discharging takes place at normal working speed without interrupting the work. The efficiency of utilization is lower when the grain is discharge at reduced speed, or at the end of the plot.

Efficiency also depends on whether the grain is transferred to a trailer or a lorry. The discharge of grain in when stationary, in the case of unfavourable local conditions, decreases the efficiency.

Pfeiffer, A.: Profitability of milk production in India.

India possesses the largest milk producing stock in the world. In spite of this, the milk production does not cover the nutrition requirements of the population. The number of cattle in India is about 180 million; the buffalo stock represents half of the total number of buffalo in the world; and there are nearly 70 million goats. Thus, on the basis of the number of animals the milk production potential should be greater in India than anywhere else. However, owing to the religious traditions which forbid using cattle and buffalo for nutrition purposes, this quantity of livestock is not sufficient to satisfy the protein requirements of the population.

In this study the author deals with the profitability of milk production and the problem of increasing the volume. He points out that although the number of animals is extremely high, it is stagnant, because in practice the animals are only used for draught work, and under the extensive husbandry conditions the milk yield is very low. It is characteristic of the latter that only about 50% of the projected amount of milk is produced. The situation could be improved by producing cheaper milk through an intensive husbandry system.

The problems of intensive milk production are as follows:

Since agriculture is organized on the lines of capitalist production, the methods used in socialist farms cannot be applied. The difficulties are further increased by the extremely low living standards of the population.

With a view to increasing the volume of milk production a genetic selection of the livestock should be carried out, the production of fodder crops increased, and the feed supply to dairy farms improved.

The following factors would improve livestock breeding:

Considerable improvement in the quality of the livestock could be achieved with imported bulls or with genetically more valuable sperm. The buffalo stock should be selected for the best milking lines.

To improve the quality of local cows, North-American dairy breeds, Swiss brown cattle and Holstein-Friesians are used at present.

The role of feeding:

The animals are grazed, and are given only straw in the sheds. Consequently, it is necessary to grow fodder crops, for which irrigation and fertilization are indispensable. In order to ensure the supply of adequate roughage mechanization and ensiling are needed.

Milk production in the small peasant farms:

Of the 49 million small farmers 60% have holding of less than 2 ha. Since they produce milk only to cover their own requirements, milk production is a subsidiary activity in small peasant farms. For intensive husbandry financial support would be needed, and a market for the milk should be ensured. With the credits offered at present only medium and large farms are able to develop. The position of these farms is also strengthened by the use of tractors. At the same time, the farmers are seriously burdened by the payment of interest, since the rate is 10%, half of which must be paid in finished products.

The efficiency of milk production:

In the past 15 years the production cost of milk has tripled, 60% of the increase being made up by feeding costs. The price per litre is 137 rupees for cows milk 130 rupees for buffalo's milk, and 99 rupees for that of crossed breeds.

Keeping crossed breeds is more economical, as a larger volume of milk is obtained under cheaper raising and husbandry conditions.

At present milk production is not profitable in India. The situation of the small peasants is particularly difficult, and no improvement can be expected for the time being. Milk production can only be increased through an adequate level of crop production.

El-Zabab, Abo A. A.—M. A. El-Kilany: Evaluation of several select on procedures for increased lint yield in segregating generations of Egyptian cotton.

The lint yield, a complex character of cotton, depends on numerous factors. The authors evaluate various methods of selection, primarily from the point of view of which can be regarded as suitable for increasing the lint yield. Two Egyptian cotton varieties (Giza-45 and Giza-67) were used in the investigations, which included an analysis of the F_1, F_2, F_3 and F_4 generations. Of the cotton varieties grown in Egypt, Giza-45 has the highest quality.

The authors examined the amount of fibre per cotton seed, the number of seeds per ovary, and the number of ovaries per plant. The selection was based on 18 combination criteria.

They found that with a view to increasing the yield a higher number of ovaries per plant was of decisive importance, but an increase in the number of fibres per cotton seed, associated with a stabilization of the number of seeds per ovary should not be left out of consideration either during selection.

On the basis of the data obtained in the course of the investigation the authors arrived at the conclusion that the negative genetic correlations (between the number of ovaries per plant on the one hand, and the amount of fibre per seed and the number of seeds per ovary, on the other) were not so close as to prevent a simultaneous consideration of the selection parameters in question. They also observed a significant negative genotypic relationship between the amount of fibre per seed and the number of seeds per ovary, so growers are advised to apply a suitably modified form of selection in order to improve the population.

When comparing the selection methods the authors observed a hierarchic process with respect to the efficiency of lint yield increase. This was expressed in the fact that the procedures applied in the first cycle, which resulted in an increased lint yield, were even more efficient in the second cycle. On the basis of their study the authors suggest the use of a selection index ($I_{12.3}$).

Abo El-Zabab, A. A.——El-Kiany, M. A.: Correlated response to several selection procedures for increased lint yield in segregating generations of Egyptian cotton (*Gossypium barbadens* L.).

As a continuation of their earlier work the authors studied the lengths of cotton fibres in two selection cycles. They used 18 different selection methods in comparing the fibres and their components (number of fibres per seed, number of seeds per ovary, number of ovaries per plant), and evaluated the methods by comparing the results with the indices for fibres from non-selected plants.

Parallel to an increase in the amount of fibre in the F_3 generation considerable modifications were observed in the indices of non-selected plants. The modifications could not be reproduced in all cases. The authors found that besides an increase in the lint yield the strength, fineness and length of the fibres also improved.

Gutte, P.— G. Gutte: Distribution and feed value of grasses in the central mountains of Peru.

The authors summarize and cite the most important works on the grasses contained in the flora of Peru. The study mainly contains data on the central part of Peru, but of these only those dealt with in a phytosociological work by Gutte (1974) are evaluated. A plant of each species included in the study was placed in the Lima herbarium (Instituto de Botánica de la Universidad Nacional Mayor de San Marcos).

In their study the authors present data on the geographical conditions of the area examined: the Junin district of the Yauli province, and the adjacent regions. In this province the rainiest period is January and February. They also publish the phytogeographical data of the area, including some characteristic features of the vegetation. The steppe areas and the vegetation of the barren plateau are analysed in detail.

The authors give the distribution throughout Peru of the grasses found in the area examined and supply detailed data on their distribution within the area itself. They also present data on the feed value of each species. A total of 90 species are discussed, ranging from *Aciachne pulvinata* to *Vulpia megalura*. Of the 90 species, the authors note which are most frequent on the barren plateau and on the steppe areas.

Finally, the authors group the grasses from the point of view of their importance in feeding.

El-Shamma, W. S.— H. C. Ali— H. N. Ismail: The influence of water treatments on the yield and its components of bread wheat (*Triticum aestivum* L.), durum wheat (*T. durum* L.) and barley (*Hordeum vulgare* L.).

The authors carried out investigations in an experimental farm near Baghdad. The yields of various barleys and 2 types of wheat were studied for 3 years under "dry", "medium wet" and "wet" conditions. These conditions were brought about by irrigation so that the moisture content of the soil was 15, 30 and 60%, respectively. The "native" moisture content of the soil was eliminated by a gypsum layer at a depth of 30 cm which separated it from the experimental soil.

In the course of the investigations the authors found that the changing rate of irrigation caused no significant difference either in the grain yield or in the components. They established, on the other hand, that the "wet" treatment produced a larger yield.

The barley variety Baladi-265 was superior to Kenya-cular-1425 and Italia 1304 both in the number of grains per spike and the resistance to drought.

Abdel-Nasser, M.— S. A. Z. Mahmoud— A. A. M. Makawi— F. S. Ali: Studies on the nodulation of soybeans in Egypt. II. Effect of seed diffusates on *Rhizobium japonicum*.

The E_{45} strain of *R. japonicum* was incubated on a suitable culture medium in Petre dishes, and the growth inhibition effects of seed diffusates was studied. The antibacterial substance present in soybeans showed an inhibitory effect. The authors subjected the seeds to various physical and chemical treatments in order to reduce or eliminate this effect. On the basis of the experimental data they found the antibacterial substance to be thermostable, partly water-insoluble and present in all parts of the soybean.

Abdel-Nasser, M.— A. A. Makawi— A. A. Abdel-Moneim: Effect of some pesticides on microorganisms in the rhizosphere of maize, common bean, or cotton.

The authors carried out in vitro studies with maize, bean and cotton to find out how the life conditions of microorganisms present in the root zone are influ nced by the insecticide Temik and the fungicide Orthocid. According to the results, in some cases the chemicals mentioned did not influence the increase in the number of microorganisms.

They observed, on the other hand, that chemicals applied in different periods caused a certain amount of depression. In a certain sense the substances in question disintegrated the different groups and types of microorganisms in the root zone. The data presented by the authors suggest that in the growth stage of the plants there were differences in the microorganic flora depending on the chemicals applied.

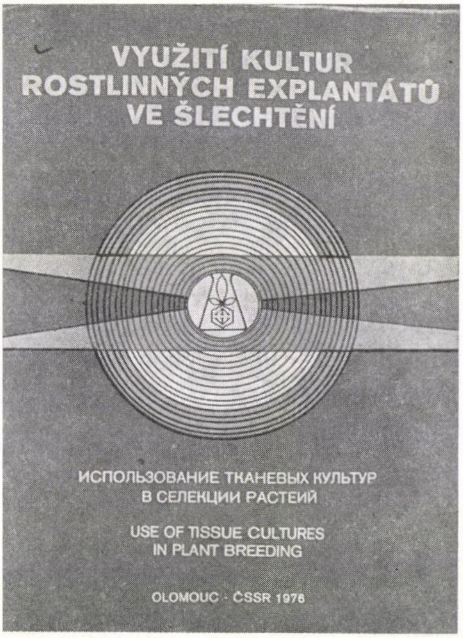
Legel, S.: Studies on the improvement of fodder production in Egypt as a prerequisite for increasing cattle and buffalo production.

In the Egyptian Arab Republic the mechanization of fodder production is considered by the author to be of basic importance from the point of view of increasing the volume of animal products, in particular those originating from cattle and buffalo.

The author indicates the environmental factors that limit the production of fodder crops. Taking these into consideration he carried out experiments in the El Gasair and Alexandria areas. According to his analyses, fodder production shows great seasonal variation, especially in summer and winter. Fodder losses in unfavourable seasons can only be compensated for by processing the fodder. The author supplies valuable data on the nutrient contents and yields of the fodder crops grown, and expresses his opinion that on certain areas the utilization of grasses may also contribute to an increase in the production level of cattle and buffalo stocks.

S. Tuboly

Novák, F.: *Use of tissue cultures in plant breeding* (Proceedings of the International Symposium, 6—11 September 1976, Olomouc, Czechoslovakia), Czechoslovak Academy of Sciences and Institute of Experimental Botany, Prague 1977.



This 650-page book contains the texts of lectures delivered at the three-language (English, Russian and Czech) international (COMECON) symposium held in Olomouc (Czechoslovakia) between 6th and 11th September 1976 under the title "Use of Tissue Cultures in Plant Breeding".

The symposium was organized by the Institute of Experimental Botany of the Czechoslovak Academy of Sciences with the assistance of the Research Institute of Plant Production and the Breeding Enterprise OSEVA. The symposium had 110 participants, from seven Eastern European countries (81 from Czechoslovakia, 7 from Hungary, 7 from the Soviet Union, 5 from the German Democratic Republic, 5 from Poland, 3 from Bulgaria and 2 from Romania).

Forty-eight lectures were delivered, all of which are found in the book; they deal with the most diverse fields of tissue cultures: general survey (5), suspension cultures (5), callus cultures (14), meristem cultures (4), embryo cultures (6), anther cultures (7), protoplast isolation and fusion (3), plant tumours (2) and in vitro pollination (2). From the point of view of utilization 8 of the lectures discuss morphogenesis, 11 deal with methodological questions, 8 with haploid production, 9 with application in breeding, 4 with resistance, 3 with mutagenesis, 3 with cytological questions, 1 with questions of alkaloid production and 1 with problems connected with ploidy.

Out of the 48 lectures, 12 have been published in Russian, 8 in Czech and 28 in English. It is a pity that the summaries are not systematically arranged, and in many cases are absent. Of the lectures published in Russian two only have English summaries, one has an English and a Czech summary, and four are not summarized in any foreign language at all. Of the lectures written in Czech three only contain English summaries, one is summarized in English and Russian, and four have no summaries written in other languages at all. The situation is still worse for the lectures published in English. Of the 28 English lectures 19 do not contain summaries written in other languages at all, Czech summaries are found in 8 cases, and Czech and Russian summaries are presented at the end of only one paper. These inconsistencies make the use of the book difficult for foreign readers.

At the beginning of the book there is a list of contents, followed by a preface by F. J. Novák, mentioning that colloquia were previously organized in Czechoslovakia in 1972 and 1974, and that these laid the foundations for the COMECON symposium.

In the introductory lecture F. J. Novák, Z. Opatrny, M. Ondrej, and P. Havránek give a detailed analysis of the most recent results in tissue culturing, discussing the possibilities of utilizing tissue cultures in producing basic breeding material and in practical plant breeding (Tissue and cell cultures — progress and utilization in plant breeding).

Following J. Rerábek's lecture on the differentiation of suspension cultures of *Solanum laciniatum*, A. Atanasov, speaking of sugar-beet suspension cultures, points out "that only suspendial cultures with single-celled origin were able to produce embryos and embryonic structures after consecutive treating with metabolites and antimetabolites of nuclein and protein metabolism".

M. Dujicková *et al.*, the authors of the lecture "The growth and morphogenesis of tissue culture of *Populus euramericane* (Dode) Guinier cv. *robusta*" succeeded in inducing callus formation and shoot and root development by changing the macroelements and hormones in the culture medium. The two lectures following this deal with callus formation in potato and wheat.

In his lecture "The induction of morphogenesis in tissue cultures — problems and remarks", Z. Opatrny gives a summarization of results and problems related with the induction of morphogenesis. This lecture is followed by one discussing the in vitro differentiation of Vicia faba.

In the lecture "Potential of protoplast, cell and tissue culture in cereal research", G. NÉMET and D. DUDITS give an account of the results of investigations made with callus and protoplast cultures of Triticum species, with special regard to plant regeneration and the fusion between various cereals.

In his lecture "In vitro techniques in garlic breeding" F. J. Novák points out that long-term callus cultures derived from the garlic meristem and leaf maintain a high organogenetic ability after a 400-day in vitro cultivation. The regenerants obtained have diploid, tetraploid and aneuploid character.

As reported in V. Chalupa's lecture "The use of regenerants from tissue culture of forest trees in the breeding", conifer and broadleaved young trees regenerated from callus tissues of the same mother tree showed similar properties.

In the lecture "Using of tissue culture method for overcoming sterility in F_1 of the interspecific hybrids *Nicotiana maritima* × *N. tabacum*", L. I. Dorosjev *et al.* gave an account of a fertile amphidiploid obtained by cultivating callus from stem segments of the sterile interspecific hybrid. When studying morphological, cytological, biological and economic characters, V. D. Popchristov and N. A. Zagorska, the authors of the paper "Study on seed progeny of regenerants obtained by tissue culture in *N. tabacum*", arrived at the conclusion that the tissue culture method could be successfully used for obtaining tobacco lines valuable for breeding and tobacco production. Following this, J. Dostál described a method under the title "Fast cytological method from using plant tissue cultures". A similar methodological result is reported in M. K. Pavlova and V. I. Maljuk's lecture "The possibility of obtaining homoploid populations of somatic cells from heteroploid culture".

Two lectures were delivered in connection with the feed-back mechanism in embryo and callus cultures of cereals: "The expression of feed-back inhibition by high lysine mutants of maize and barley in embryo cultures and its callus cultures", and "Comparison of some methods of testing cereal plants for resistance to lysine-feedback".

In relation with in vitro propagation the lecture by M. Maróti and E. Lévi, "Hormonal regulation of the organization from meristem cultures", deals with *Dianthus*, *Malus*, *Pirus*, *Pyraster* and *Prunus* species, while in the study by E. Hauzinska and K. Kaparski ("Use of in vitro propagation of carnation breeding clones — one of the ways of growing the planting stock") *Dianthus caryophylus* was the test plant. In their lecture "Some differences in embryogenesis of excised flax embryos" A. Pretová and O. Erdelská pointed out differences in growth and cell division, in vascular bundle differentiation, reserve material deposition and assimilation pigment contents.

The following papers are concerned with three important fields: mutant isolation, haploid production and protoplast culture.

The introductory lecture on mutant isolation, "Tissue culture as a tool for the isolation of mutants in flowering plants", was presented by P. Maliga *et al.*; besides the achievements and problems they also discussed the possibilities of application in practice, e.g. lines resistant to temperature extremes, high salt concentrations and toxins. The title of the following lecture is "Chemical mutagenesis in *Dioscorea deltoidea* Wall. somatic cell culture".

A comprehensive lecture on haploidy was held by M. Zenkteler under the title "Induction of haploid plants from anthers cultured in vitro". The introduction is followed by a number of articles discussing haploidy and in vitro androgenesis. An account is given of investigations made by Z. B. Samina and Nguen Tchi Dao on tomato, by B. Kubicki *et al.* on apple, by A. Stoljarz on barley, by N. A. Zagorska *et al.* on tobacco, and by F. J. Novák *et al.* on wheat.

As regards protoplast isolation and fusion, only the initial results are reported by the authors. The results published by A. A. Kucko and R. G. Butenko were obtained on various *Solanum* species, while the data presented by P. Havranek and Z. Opatrny refer to *Cucumis sativus* infected with cucumber mosaic virus, as well as to various *Allium* species.

In addition, the studies related with virus, mycoplasm and fungal infections are definitely worth mentioning. J. Svobodová gave an account of tuber formation from S-virus infected potato callus, S. F. Lukjanjuk and V. G. Ivascenko reported on investigations into the cytopathogenic action of toxins in some species of *Fusarium* and other fungi by methods of cell culture in lupin and maize, while E. Petru and M. Ulrychová discussed problems of mycoplasm persistence in callus tissues derived from some host plants of the family *Solanaceae*. The lecture by J. Hrib and V. Rypácek, "Using tissue cultures of wood species for the study of the substrate specificity of wood-destroying fungi", also belongs to this field of subjects.

With respect to plant tumours, two lectures were delivered: "*Agrobacterium tumefaciens* and induction of plant tumours: auxotrophic mutants of strain 37,400 that affect tumour-inducing ability and tumour phenotype" and "Tissue cultures of crown-gall tumours as an experimental model system".

The introductory lecture on in vitro pollination, "Some problems of placental pollination", was presented by Z. Sladky. This was followed by two other lectures: V. Balatková *et al.* discussed physiological questions related with in vitro pollinated placentae, while K. Niemirowicz-Szczytt and A. Wyszogrodzka gave an account of in vitro pollination in the family *Cucurbitaceae.*

The utilization of tissue cultures and the production of secondary metabolic products was only dealt with in one lecture: "Phytochemical analysis of tissue cultures of camomile grown in dark and light" (É. Szőke *et al.*).

In the article "Research for plant tissue development in Hungary" at the end of the book the Hungarian professor Maróti gives detailed information on the researchers and institutes involved in Hungarian tissue culture research, and presents their aims and achievements. The book has the disadvantage that the other COMECON countries did not prepare similar summaries, which would have given some insight into the tissue culture research programmes of the socialist countries.

All in all, in spite of its deficiencies, the book "Use of Tissue Cultures in Plant Breeding" reflects fairly well the results of tissue culture research in the COMECON countries in the mid-seventies. The organizers, headed by F. J. Novák, should definitely be praised for arranging the first symposium on tissue culture and for publishing the lectures presented there within a very short time.

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